MECHANICAL ENGINEERING

May 1961

DESIGN ENGINEERING '61

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CONFERENCE AND SHOW, 149 FLOOR PLAN OF SHOW • LIST OF EXHIBITORS • HOW TO GET TO COBO HALL • ASME CONFERENCE PAPER DIGESTS • PROGRAM IN BRIEF • ORDER FORM FOR PAPERS

LUBRICATION REVIEW, 67 Part Two of A Digest of the Literature for 1959-1960 • GEAR LUBRICATION • ROLLING-ELEMENT BEARINGS • FLUID-FILM BEARINGS • LUBRICANT PROPERTIES

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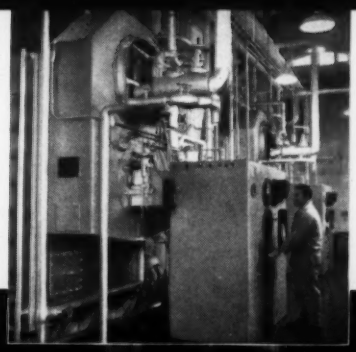
DESIGN ENGINEERING ISSUE

5 Million Cookies an Hour



Nabisco relies on B&W Package Boilers to supply heat for buildings and steam for all of their process requirements where giant ovens produce 177 million pounds of bakery products annually.

In Nabisco's $15,000,000 plant at Fair Lawn, N. J., three B&W Package Boilers are used to heat the plant, and to supply steam for process equipment. Operating at 130 psi and 338 F, the three oil-fired boilers deliver a total of 84,000 lb of steam per hour. Each of the plant's ovens are the length of a football field and these immense bake-ovens process up to 5,600,000 cookies an hour! Needless to say, dependable process steam supply is a must in this massive baking operation. That's why Nabisco selected B&W Package Boilers to provide the needed steam.

Dependability, however, is only part of the story. Budget-minded Nabisco management has found the cleanliness of operation, high fuel economies, flexibility, rapid response to demand, and maximum capacity in minimum space afforded by B&W Package Boilers equally attractive features. They also appreciate the assurance that B&W's nationwide service organization will be promptly and economically available if needed—at *any* time during the life of the boilers.

Supplying heat and process steam for a modern baking plant like Nabisco's is further evidence in action of dependable steam generation by B&W. Whatever *your* steam requirements . . . whatever your most economical fuel, B&W has the boiler best suited to your application. Your local B&W representative has all the facts on your area. Call him soon. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

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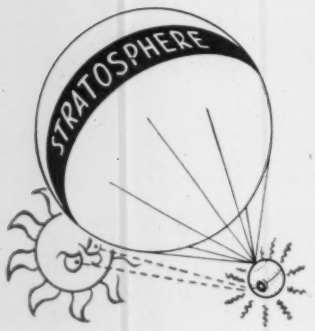

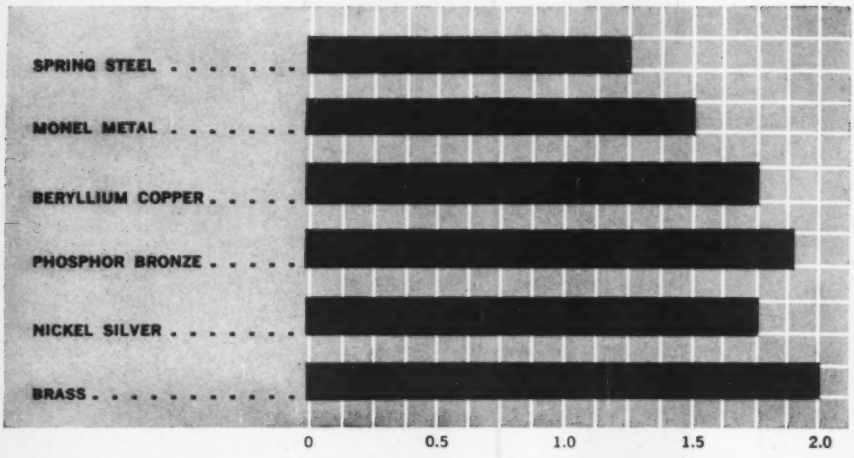

PER CENT DECREASE IN STIFFNESS WITH 100°F. INCREASE IN TEMPERATURE

How Temperature affects spring stiffness

When service or operating temperatures are above room temperature, spring selection must take into consideration several factors usually of little consequence in ordinary service.

These are loss of strength, thermal expansion, deflection, drift and hysteresis.

The first effect — loss of strength — is usually the most serious. What happens is that the safe stress carrying capacity of the spring material decreases at higher service temperatures and springs of ample strength at room temperature may be too highly stressed when heated.

These effects may be small in many cases, but under some conditions they may be important, particularly when temperatures vary over a wide range. Where an accurately determined spring strength at elevated temperature is desired, the specifications covering load test at room temperature should be corrected for the change that will occur. The approximate amount of correction for 100° F change in temperature for various materials is shown in the chart above.

With today's increasing high-temperature problems in many fields, proper spring selection is more than ever important. The subject is discussed in our latest pamphlet, "High Temperature Springs." Write for your copy.

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MECHANICAL ENGINEERING

PUBLISHED BY
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

Contents

VOLUME 83 • NUMBER 5 • MAY, 1961

THE COVER

This picture is our symbol of this year's ASME Design Engineering Conference and the concurrent Design Engineering Show. They will be held May 22–25, at Detroit's new exhibition building, Cobo Hall. As in previous years, the Show—and the Conference of ASME's Machine Design Division—will be Mecca for mechanical engineers, a gathering of the leaders of this American art. Program: See pages 154–156.

THE "ARTIST" ENGINEER.....**C. J. Freund** 38

As an engineer, you'll tend to be scientist, or artist. The artist translates the scientist's schematics into hardware, adapting and designing —and managing. He's the facer of facts, the builder.

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WHICH DRIVE?.....**G. W. Younkin**
PRODUCIBILITY.....**C. E. Warner and R. L. Berg**
ADHESIVES.....**H. R. Butzlaff and K. F. Charter**

Competition: It's here, calling for new thinking in the design of machinery. Your know-how must include understanding of materials other than metals, and advanced knowledge of production methods.

LOADING A TIRE-CURING MACHINE.....**L. E. Soderquist** 56

Not only faster, but better. Molds stay hot, diaphragms may last longer, variables can be eliminated, production goes up. The move toward automation comes gradually here, an operation at a time.

ENGINEERING'S GLASS HOUSE.....**S. W. Brossman** 60

Something's got to give: On the one hand, Engineering, wanting to improve the product; on the other, Production, wanting to produce. Does your engineering department fail to get the whole picture?

THE ORLANDO GAS TURBINES.....**C. H. Stanton and H. C. Luff** 61

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Just what is acceptable research? Does the element of application—inherent in engineering as in medicine—disqualify engineering as a subject for university research? Not if we value creativity.

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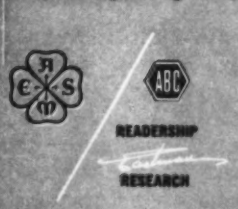
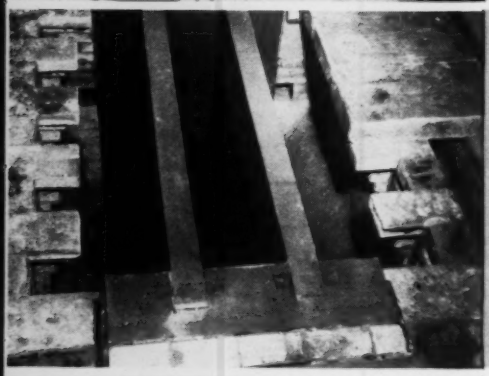


Report from Carborundum:

How industry is solving unusual problems with unusual refractories

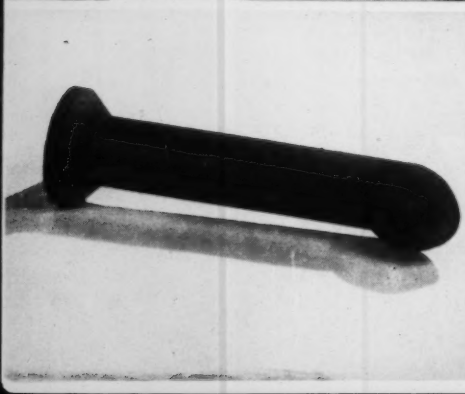
PACKING EXPANSION JOINTS:

CERAMIC FIBER WITHSTANDS 2300°F; EASILY PACKED; OBTAINABLE IN MANY FORMS. FIBERFRAX® ceramic fiber extends the temperature ceiling of fibrous insulating materials; opens new application areas. In rope or bulk form, it makes an excellent expansion-joint packing for refractory furnace walls. It is light in weight, highly resilient, does not shrink, is impervious to heat shock, and is inert to most furnace atmospheres. Various forms of FIBERFRAX — e.g. cloth, board, paper etc. — also offer advantages for gasketing, sealing, wrapping, lining, encapsulating, blanketing and jacketing.



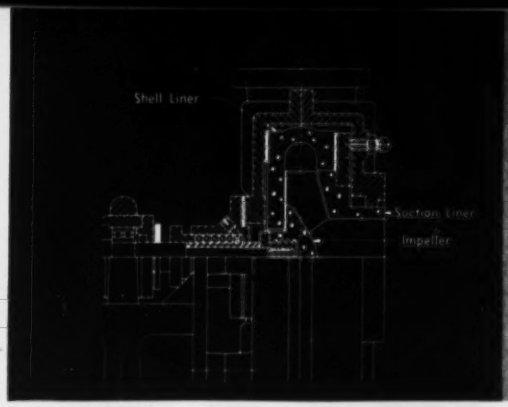
ZINC ORE REDUCTION IN VERTICAL RETORT:

RUGGED REFRACTORY WALLS CONDUCT HEAT FAST, STAY GAS TIGHT. Five million Btu's must be transferred through refractory walls such as shown at left for every ton of zinc produced. High heat conductivity — 11 times that of firebrick — is provided by CARBOFRAX® silicon carbide retort walls. Internal temperatures reach 2000°F. Other important refractory properties: great physical strength at high temperatures, chemical inertness, and unequalled abrasion and erosion resistance. Low permeability is also important because gas-vapor mixtures produced in the retort must be contained.



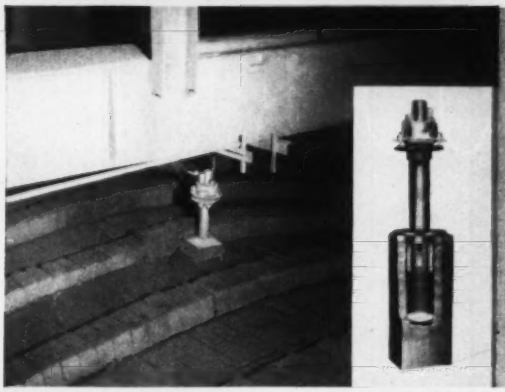
SPRAY NOZZLE FOR CORROSIVE SERVICE:

REFRACTORY REPLACES METALS—RESISTS HIGH TEMPERATURES, CORROSION, THERMAL SHOCK. The nozzle illustrated sprays a 15% solution of SO_2 in water at 150°F into a chamber operating at over 1700°F. Conditions involve severe thermal shock and corrosion. Previously used metal nozzles often lasted less than two months. Nozzles made of Carborundum's silicon carbide have shown no signs of failure after five years of service — another example of how these versatile refractories can take unusual forms to meet highly specialized problems.



PUMPING ABRASIVE SLURRIES:

REFRACTORY PARTS FOR PUMP RESIST WEAR, OUTLAST HARDEST METAL ALLOYS. Development of REFRAX®, a silicon-nitride-bonded silicon carbide, makes it possible to use refractories in many applications usually requiring metals. It can be formed with high dimensional accuracy as well as a high finish. Examples of use are impellers and shell liners in "Lightning" sand and gravel pumps made by Kansas City Hay Press Co. Comparative performance during a six months' test pumping 150 GPM of water with 20% silica sand against a 70-foot head has shown that REFRAX parts give more than five times the life of duplicate parts made of nickel chrome alloy.



MAKING 200 TONS OF STEEL BEHAVE:

TARGET BLOCK HELPS KEEP FURNACE TEMPERATURE AT MAXIMUM PRODUCTION LEVEL. The temperature detector shown in the open hearth roof at left is mounted in a hollow silicon carbide block. The detector is focused on a target disc made of another one of Carborundum's refractories — REFRAX refractory. Radiated heat from the disc provides a constant check on roof temperature . . . assures maximum production without danger of "losing" the roof. These two refractories provide the necessary properties of high heat conductivity, resistance to high temperatures and furnace gases and exceptional hot strength. Device is manufactured by Leeds & Northrup Co.

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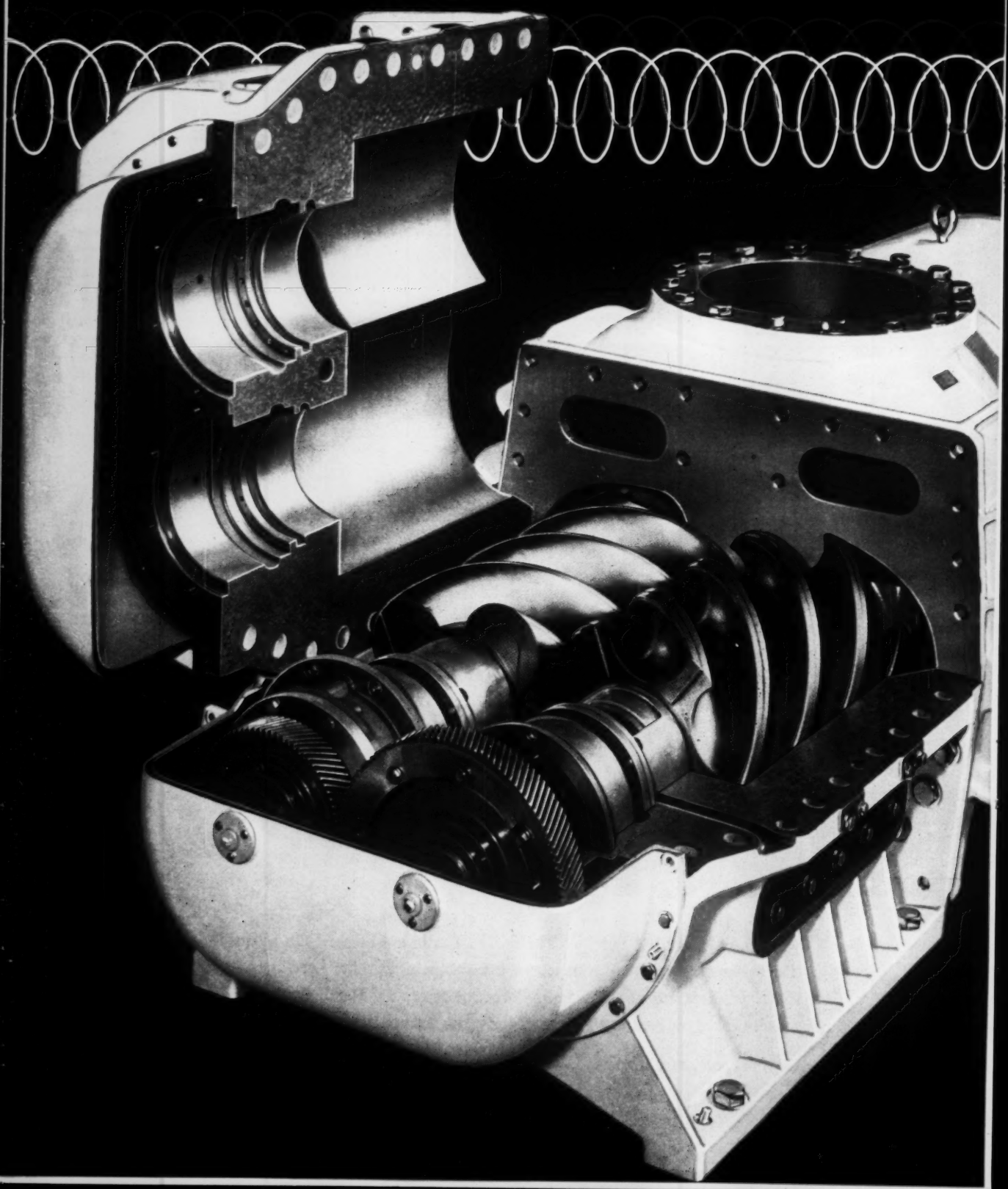

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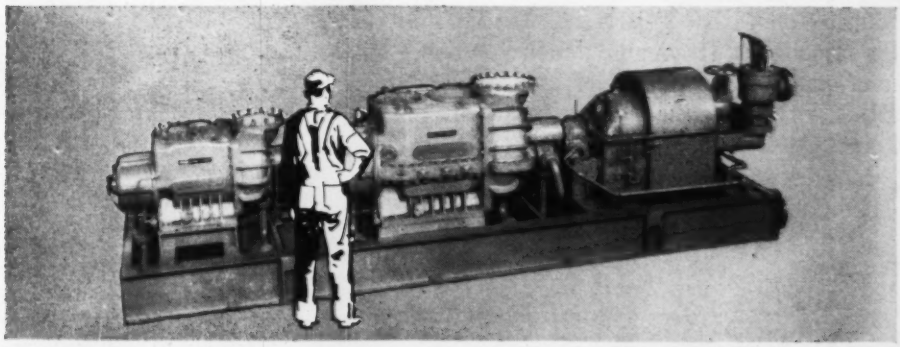

Skid-Mounted, Tandem Rotary Compressor ready for installation at Deere & Company, Waterloo Tractor Works.

Model 200L3/132L3 Fairbanks-Morse Rotary Air Compressor for 12,000 cfm, 110 psig. with 2600 h.p. steam turbine drive.

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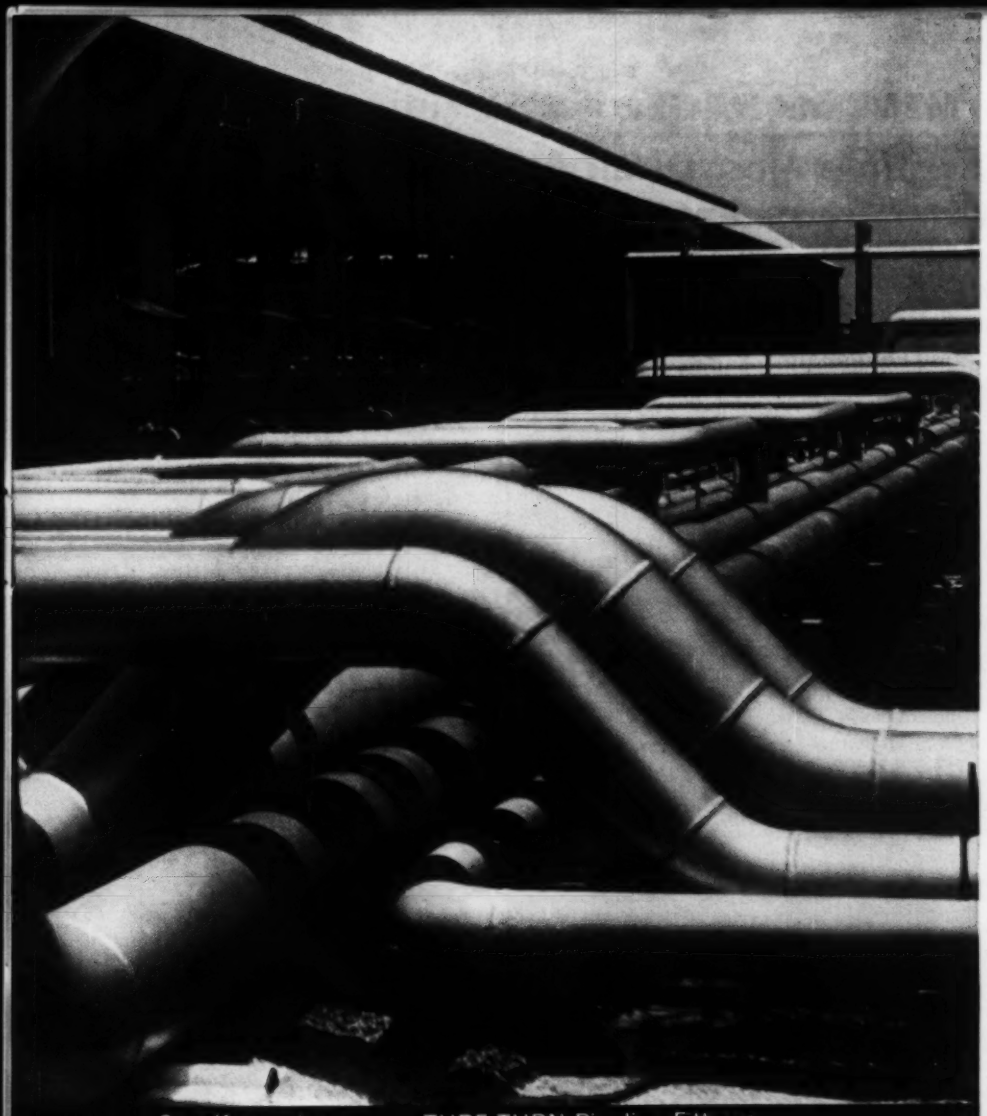

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A Nalco DEPARTMENT MANAGER

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Answer: Design, modification, improvement, and achievement of maximum economy in operation of water treatment facilities are highly specialized chemical engineering fields. Constant research and long experience in these fields enable Nalco engineers to supplement—*not* replace—the efforts of a company's staff by providing up-to-date information in their special fields.

Question: How does Nalco Consulting Service differ from the services of design consulting engineers?

Answer: Again, remember the specialized nature of water treatment engineering. Rarely can a company or consulting firm afford to maintain a staff of engineers who devote their entire energies to water treatment. Nalco, however, *does* have such a group of water treatment specialists that can act as an extension to the staff of the design engineer. These men have not only knowledge and experience in the intricacies of each of the specialized areas of water treatment, but the constant association with the rapidly changing technology of the field required to keep their information accurate and up-to-date.

Question: What return on investment does the cost of a Nalco consulting program provide?

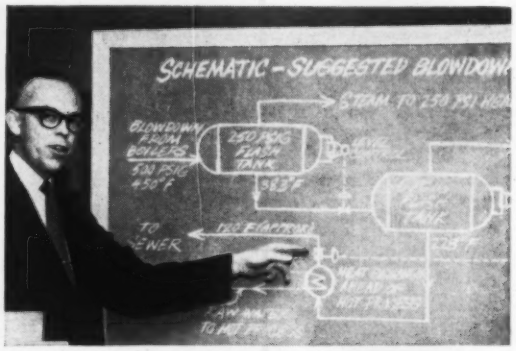
Answer: Nalco Consulting Service reduces plant construction costs and saves *your* engineers' time. For example, assume that you need a new or completely modernized ion exchange water treatment plant. Nalco Consulting Service will help your engineers and/or design consultants establish the basic type and size of plant needed, *before* requests for bids are issued. Potential suppliers can then return bids faster and more economically. Also, your engineers can evaluate bids in a fraction of the time required for evaluation of bids on a variety of plant types. This reduces the overall cost of the system and releases the men involved for other projects.

Question: How is Nalco Consulting Service useful to an existing plant for which no immediate expansion is planned?

Answer: Few plants require or can afford a *full-time* water conditioning engineer – yet *all* plants find at times that they need the services of such an engineer. Nalco meets this need by supplying plant operators with the assistance they need, when they need it, to an extent determined by mutual agreement. Consulting service prevents many problems before they occur by anticipating the need for changes in chemical treatment control and application—giving you maximum benefit from every dollar spent on water treatment chemicals.

Question: Isn't consulting service usually supplied, free of charge, with the purchase of water treatment chemicals?

Answer: *Product application assistance* is offered for specific chemicals. Consulting provides an overall *program*. The complexity of many of today's systems requires attention to all phases of operations. While product application assistance is an important Nalco service to industry, often it should be supplemented with a consulting arrangement which provides the intensive and effective integration of *all* water treatment into a successful program.



Selden K. Adkins, Manager, Nalco Consulting Service Department

Question: What do you mean when you say "the highly specialized nature" of chemical engineering as applied to water conditioning?

Answer: No one engineer can know every single detail that is important in each phase of an overall water treatment program. Coagulation, filtration, stabilization, softening, sludge conditioning, ion exchange, slime and microbiological control—all these and many more must be considered. Nalco's coagulation, stabilization, power industry chemicals, process antifoams, cooling water, and microbiology departments maintain an effective working knowledge of each of these special areas of water treatment. Each department manager is an expert in his given field, and is assisted by an average of 25 staff and laboratory personnel. Nalco's Consulting Department draws on the specialized knowledge of each of these groups to provide the engineering knowledge needed in each plant. By coordinating the efforts of all these specialists and utilizing the knowledge and experience of our national field force, Nalco can provide precise information to get successful results. That so many departments are vital in our operations indicates the degree of specialization necessary.

Question: How can a company that sells chemicals be a "true" or impartial consultant?

Answer: Regardless of affiliation, consultants are responsible for producing effective results. Nalco consultants have nothing to gain—and everything to lose—by recommending any chemical or method not in the best interest of the client. Water treatment products offered by Nalco (or any reputable company of this type) are usually special blends, each designed to do a specific job under a specific set of conditions. These specialized products would not exist if there was an *exact* equivalent "open market" chemical available. The Nalco Consulting Department recommends the most suitable chemical for a given situation—regardless of whether or not it is a Nalco product. The single objective of Nalco Consulting Service is to provide the client with maximum treatment efficiency, regardless of which chemical or equipment is used. Chemicals are no more than tools to the consulting engineer—what he provides are programs, methods, and results.

Suggestion: Ask your Nalco Field Representative, or write for illustrated 16 page Bulletin D1 for information on Nalco Consulting Services.

NALCO CHEMICAL COMPANY

6317 West 66th Place • **Chicago 38, Illinois**

Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
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Nalco ®... **Serving Industry through Practical Applied Science**

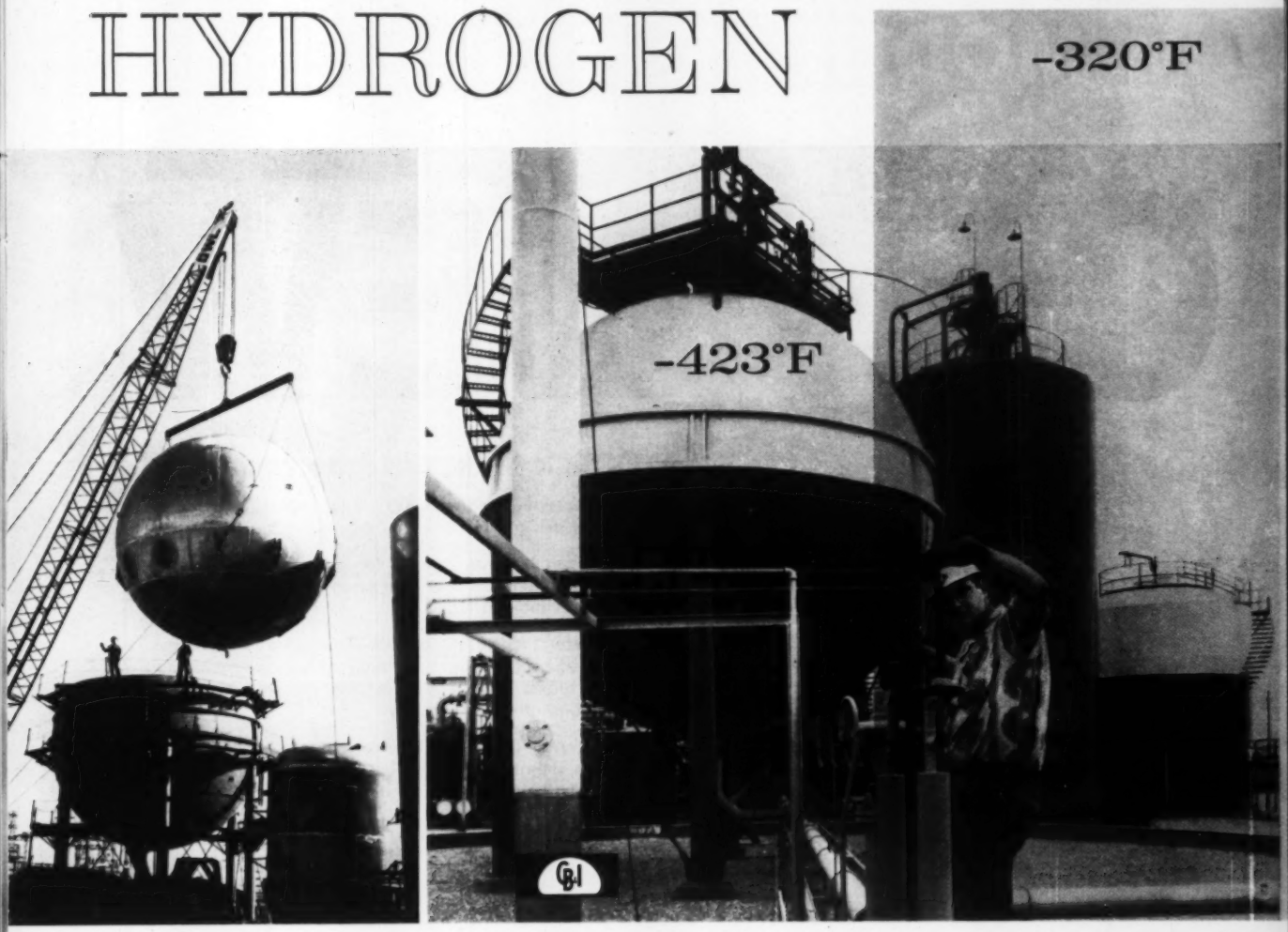
Nalco CHEMICALS
Nalco SERVICES

Circle No. 93 on Readers' Service Card

First privately owned and operated space-age plant furnishes liquid hydrogen to missile centers and industrial users

NITROGEN

HYDROGEN



These double-wall cryogenic storage tanks play a vital role in the first privately-owned plant to supply liquid hydrogen on a large-scale commercial basis. Hydrogen is stored in the sphere at −423°F and nitrogen in the cylindrical tank at −320°F. Located in Torrance, Calif. and owned by Linde Company, Division of Union Carbide Corporation, the plant will deliver 3,300,000 lbs. of liquid hydrogen yearly to missile centers. Both tanks were designed (using Linde-approved designs), fabricated and erected by CB&I, world's most experienced builder of cryogenic vessels.

ABOVE: Aluminum inner shells and carbon steel outer shells were used for the two cryogenic tanks. The spherical tank is 28 ft. in diameter and the cylindrical tank 21½ ft. Special insulation is between the shells.

TOP LEFT: The inner sphere is suspended in the outer sphere by stainless steel rods positioned around the perimeter. Resting on the ground nearby is the aluminum inner shell of the cylindrical nitrogen tank.

LEFT: A trailer is being loaded with liquid hydrogen for delivery to missile centers, other government installations, or industry.

CB&I

Chicago Bridge & Iron Company
332 South Michigan Ave., Chicago 4, Ill.
Offices and Subsidiaries Throughout the World

CB-612

Circle No. 34 on Readers' Service Card

Now...a completely self-cased, MODULAR BOILER

C-E's NEW

DESIGN HIGHLIGHTS OF THE VU-60

Modular construction makes it possible to assemble custom designs from standardized components.

Boiler can be proportioned for best combustion, heat absorption and gas flow even when space conditions are limited or difficult.

Completely self-cased, the VU-60 is an all-welded gas-tight and pressure-tight envelope of finned furnace and boiler tubes. This results in less non-working weight per pound of steam capacity.

No external ductwork. The bottom of the boiler is a plenum chamber which allows air to flow direct from the air heater to the burner windbox.

Number of field-welded pressure parts is greatly reduced.

Cross flow baffling and symmetrical boiler bank mean low draft loss, no sluggish gas flow in any pass.

Requires only a simple, reinforced concrete slab. No conventional roller supports required.

Paneled construction cuts erection time.

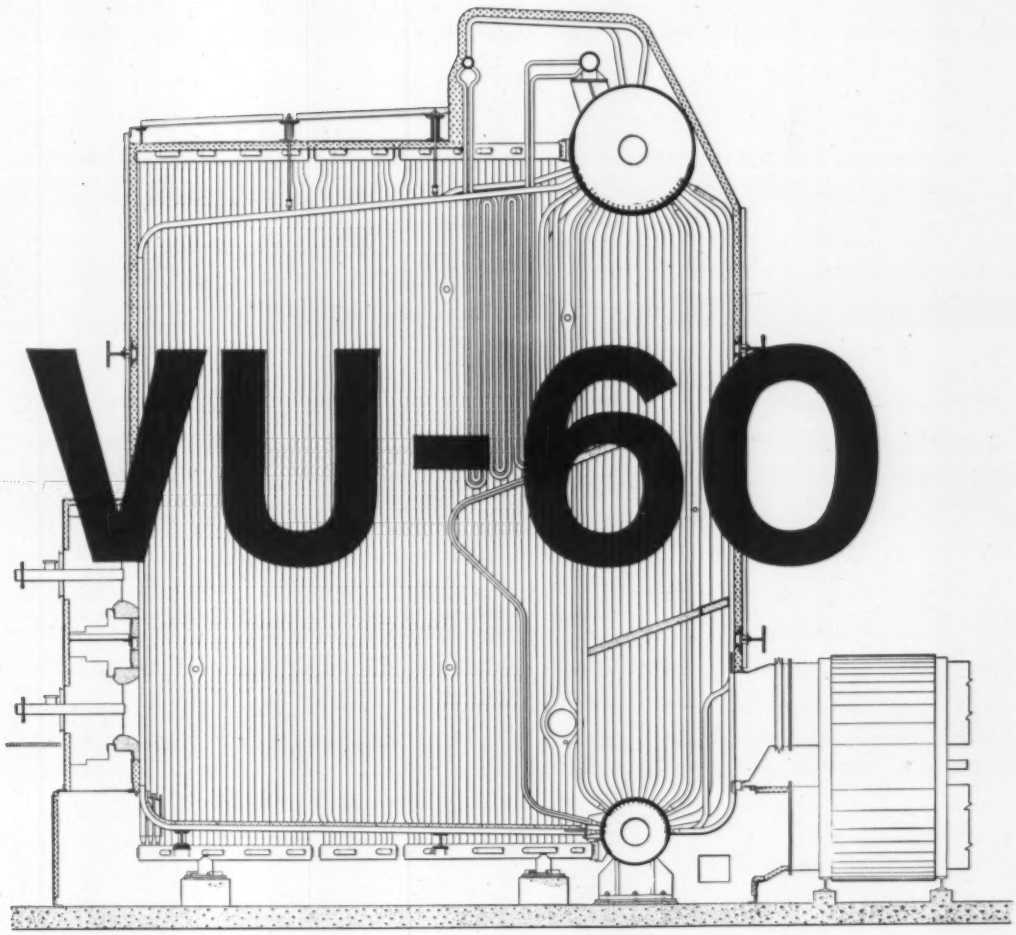
No air heater supporting steel is required.

For pressurized or induced draft firing. When pressurized, unit does not require induced draft fan.

VU-60 SPECIFICATIONS

Capacities:	100,000 to 250,000 lb per hr
Design pressures:	250, 500, 750, 1000 psi
Steam temperatures:	To 900 F
Fuels:	Oil and/or gas
Firing:	Horizontal (front wall) or tangential
Size increments:	Depth — twelve Width — eight Height — three
Steam drum sizes:	Four

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;



The VU-60 Boiler is a new and logical extension of C-E's service-proved VU series. Like all VU units, it is completely integrated, symmetrical in design, uncluttered and uncomplicated. Based on a standardized modular concept, it offers greater flexibility, yet stays within the bounds of solid and proven practice.

The VU-60 is a functional boiler. Completely self-cased, the exterior walls of this unit (furnace and boiler) are composed of finned tubes, shop welded into panels. The fins between panels are field welded to form a gas- and pressure-tight structure. Insulation is applied directly to the outside of these walls and is covered by pre-formed, field installed metal lagging. Thus non-working weight and bulk is reduced to a minimum.

The VU-60 is economical, it is dependable, it is accessible. It is easy to install and will meet your most exacting steam needs. Why not write for further information, or, if you prefer, contact the C-E office nearest you.

COMBUSTION C-E ENGINEERING

General Offices: Windsor, Conn. • New York Offices: 200 Madison Avenue, New York 16, N. Y.

Canada: Combustion Engineering-Superheater Ltd. C-300

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

Circle No. 38 on Readers' Service Card

POWELL MAKES IT A SIMPLE MATTER

To find the right valve for power plant installation, just call Powell. It's that simple, since Powell can supply just about any type of valve you may need to control water, oil, gas, air, steam or corrosive fluids.

What's more, you don't have to wonder about Powell performance. It's built-in through sound engineering, development, materials and workmanship . . . and proved day in, day out.

So, remember, finding the right valve can be a simple matter when you specify Powell. For further information, call your nearby Powell Valve Distributor (there's one in every major city), or write us direct.

115th year of manufacturing industrial valves for the free world

POWELL HIGH PRESSURE **VALVES**

THE WM. POWELL COMPANY CINCINNATI 22, OHIO

Circle No. 106 on Readers' Service Card

← MIDGET OR MAMMOTH

Scarcely a handful, this duplex Twin Disc Clutch, only 3" in diameter, is designed to run in oil.

This huge 42" Twin Disc Air Clutch has a torque capacity of 166,800 lb.-ft.

There's a Twin Disc Clutch to handle your power transmission job

MECHANICAL

Small wet or dry clutches in 3.5" and 4.5" sizes with capacities to 14 hp. Enclosed units in sizes from 5.5" to 11.5" and capacities from 14 to 112 hp. Large heavy-duty clutches for high-torque duty; sizes to 36" and capacities to 1050 hp.

PNEUMATIC

Twin Disc Air Clutches provide more compact remote control without complicated linkage. Lighter weight reduces inertia mass, lessens shock loading during starting cycles. Sizes from 8" to 42" for every air-actuating application. Capacities from 29 to 1642 hp. Max. torque: 166,800 lb-ft.

HYDRAULIC

Oil-actuated multiple-plate clutches for high-speed, high-energy operation. Compactly designed, readily adapted to push button control. Available with optional integral oil collector. Sizes from 3" to 7". Capacities to 137 hp and 690 lb-ft. of torque.

ELECTRIC

Direct-acting wet-type electro-magnetic clutches with stationary coils. Annular flux-through-plates magnetic principle provides high torque capacity and compact design. Compensates automatically for wear. Sizes range from 3.3" to 11.5" with torque ratings from 14.5 to 1812 lb-ft.

Circle No. 128 on Readers' Service Card

Send for Bulletin 314

This 20-page bulletin gives details and specifications on the complete line of Twin Disc Friction and Fluid Drives. Write to TWIN DISC CLUTCH COMPANY, Racine, Wis.

TWIN DISC

TWIN DISC

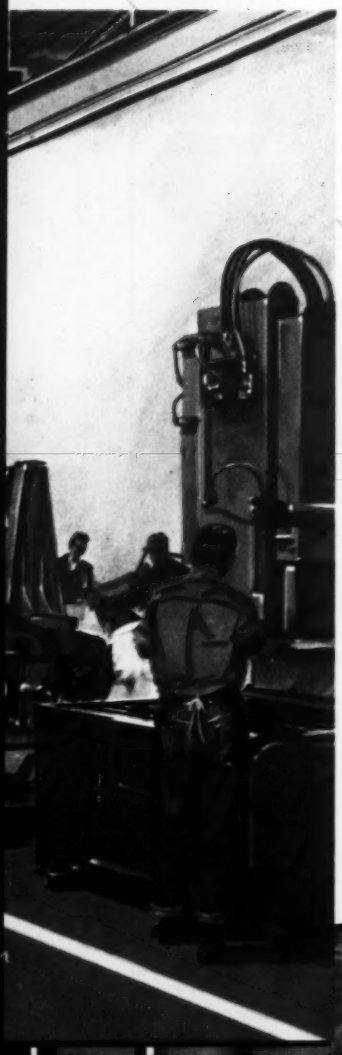
Friction Clutches and Fluid Drives

Circle No. 114 on Readers' Service Card →

RUST-OLEUM

NEW COLOR

HORIZONS System



STOPS RUST AND PROVIDES LASTING BEAUTY

Gone are the days when color was used for the sake of color alone. Today, color is functional—helping to improve morale and increase efficiency—serving to color-code and mark safety areas, etc. The Rust-Oleum New Color Horizons System goes even further. It combines four important factors (1) the ability to stop rust, (2) smart, modern color harmony, (3) the durability to last and last, (4) ease of application that saves time, money, and metal. See how this system can bring lasting beauty to your plant, machinery, equipment, tanks, fences, etc. Your Rust-Oleum Industrial Distributor, with your Rust-Oleum Factory Specialist, will be happy to survey your plant and provide complete recommendations. Prompt delivery is assured from Industrial Distributor stocks in all principal cities of the U.S., Canada, and many countries around the world.

Faced with coating problems like these? Heat resistance, water resistance, chemical resistance, floors, galvanized metal, coatings that will dry in less than thirty minutes? Rust-Oleum, in its various systems, can be your answer. Call your Rust-Oleum Industrial Distributor, or write for the facts.

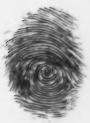
Apply Rust-Oleum 769 Damp-Proof Red Primer directly over sound, rusted surfaces to STOP RUST and cut maintenance costs

Just scrape and wirebrush to remove rust scale and loose rust—then brush Rust-Oleum 769 Damp-Proof Red Primer right over the remaining rust. Its **specially-processed** fish oil vehicle penetrates rust to bare metal as proved in radioactive tracing studies. You save time and money, as costly surface preparations are usually reduced.

RUST-OLEUM®

See our catalog in Sweet's.

STOPS RUST!®



Distinctive as your own fingerprint.
There are imitations,
but only **one** Rust-Oleum.
Accept no substitute.

PROVED THROUGHOUT INDUSTRY FOR OVER THIRTY-FIVE YEARS

You take the brush! Try a free test sample!

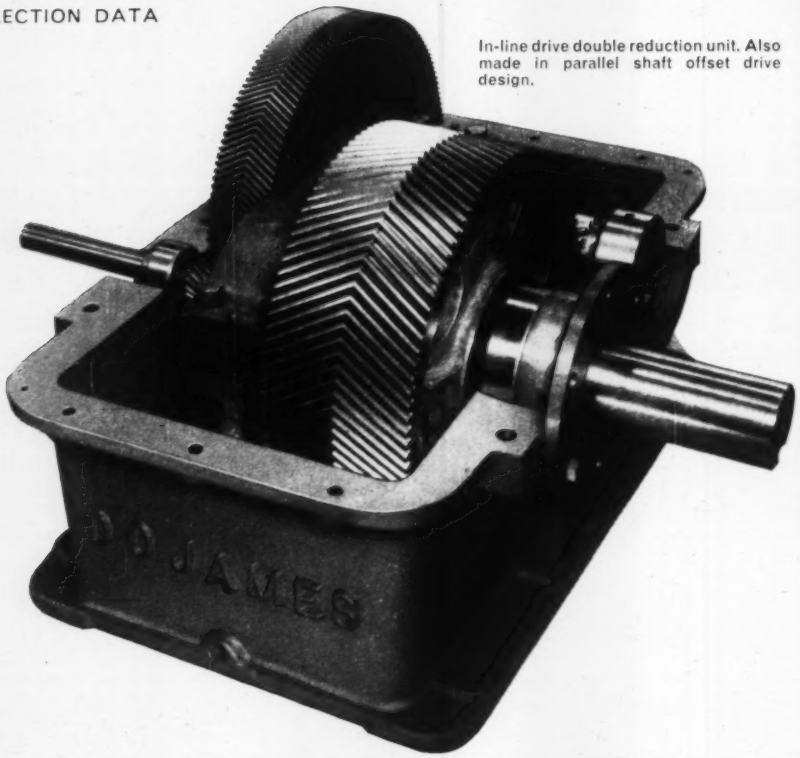
ATTACH TO YOUR LETTERHEAD

RUST-OLEUM CORPORATION
2984 Oakton Street • Evanston, Illinois

At no cost or obligation, please send me:

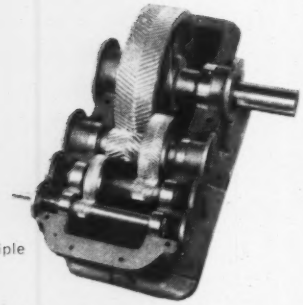
- ☐ New full-color catalog on New Color Horizons System and specialized Rust-Oleum systems, including color charts and applications.
- ☐ FREE TEST SAMPLE of Rust-Oleum 769 Damp-Proof Red Primer.
- ☐ Please have your representative contact us to discuss a plant survey.

D. O. JAMES SPEED REDUCER SELECTION DATA



In-line drive double reduction unit. Also made in parallel shaft offset drive design.

for heavy loads, use herringbone reducers



Parallel shaft offset drive triple reduction.

When you require heavy-duty drive units, D. O. James herringbone gear reducers provide unequaled advantages:

Strongest tooth form — due to the arch-like construction of the tooth and large 30° helix angle.

Greatest load-carrying capacity — large multiple-tooth contact in plane of action — full width of the tooth face is utilized.

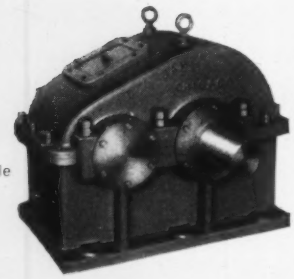
No side thrust — thrusts of the opposing helices tend to balance each other, distributing load evenly across the face of tooth. Housing is economical because no provision for side thrust need be made, nor are thrust bearings required.

Improved splash lubrication — an oil film is formed and preserved by the wedging action of the teeth.

High efficiency — 98% on single reduction units.

These reducers are made in 110 standard sizes, single, double, and triple reduction, 2:1 to 370:1 ratios, .5 to 5000 hp.

For complete information, call your D. O. James representative or write today. Ask for Catalog 40-E.



Parallel shaft offset drive single reduction.

D. O. JAMES GEAR MANUFACTURING CO.
1140 West Monroe Street, Chicago 7, Illinois
Since 1888, every type of cut gear and gear reducer

D.O.James

...where you always get good gearing

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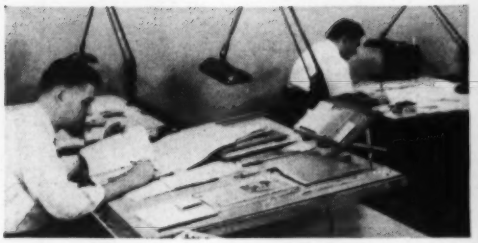

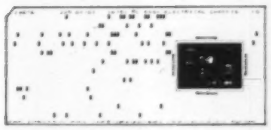

Memo to the engineer who hasn't used microfilm cards as yet!

No doubt you've read about Recordak precision microfilm images mounted in aperture cards, and how they are speeding routines in drafting rooms large and small.

But you may have some questions . . . are perhaps wondering just how they can help on your job.

For a start, consider a few of the advantages: you'll be able to keep all of your drawings—thousands of them—in a small card file at your finger tips. You'll be able to refer to any one of them in seconds in a RECORDAK Film Reader . . . no more "waiting" for costly prints every time you want to check a drawing. Whenever needed, low-cost, paper facsimiles—or duplicate film cards—can be made in seconds directly from the master card.

There's much more to the story. You must see for yourself how Recordak precision microfilming reproduces drawings of all types and ages with remarkable uniformity; how it gives you "drawings in miniature" that more than meet DOD requirements. Then you'll have a better idea why so many leading companies use Recordak microfilm-in-cards.

Free booklet goes into more details on precision microfilming available through Recordak or a microfilming dealer of Recordak.

RECORDAK®

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originator of modern microfilming

—now in its 34th year

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Send booklet describing RECORDAK Engineering Drawing System and name of nearest microfilming dealer of Recordak.

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WHY PAY FOR METAL WASTE?

Here is how to cut costs on your next tube order . . . by eliminating excessive metal waste and unnecessary machining time.

NOW FOR THE FIRST TIME you can order the exact size tube O.D.'s you need from 2.25" to 50" with wall thicknesses from .25" to 8". An exclusive "first" in centrifugally spun tubing — the ACIPCO CERAM-SPUN® process* makes this revolutionary development possible.

YOU BUY WHAT YOU NEED . . . NO MORE. Furthermore, the cost of unwanted crop ends can be eliminated and tubes can be cast to specified lengths from 4 feet to 20 feet. Longer lengths are made by welding.

OTHER ADVANTAGES? ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — save you the delays and excessive costs that often result in buying from multiple supply sources.

Let us tell you more about ACIPCO CERAM-SPUN® . . . contact us today. ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

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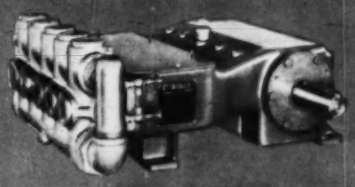
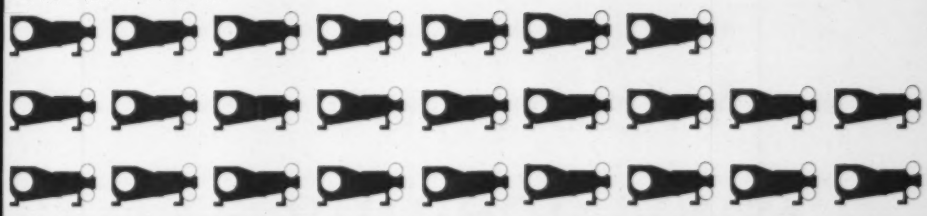
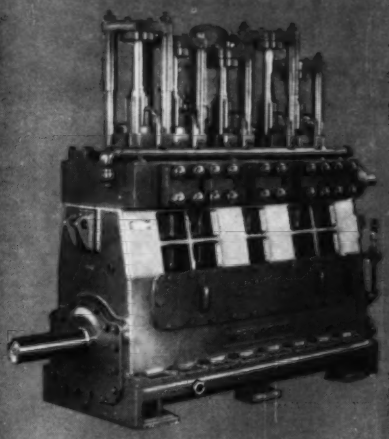
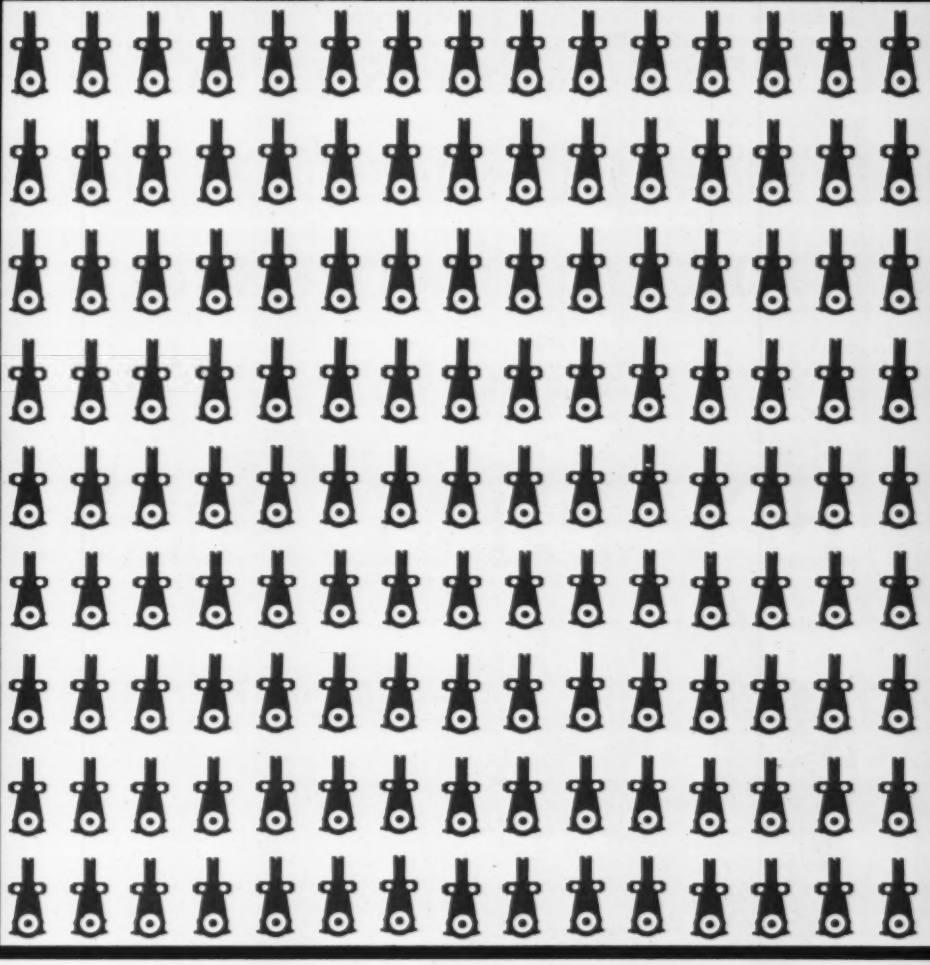


HORIZONTAL PLUNGER PUMP
25 sizes—15 to 160 HP





VERTICAL PLUNGER PUMP
135 sizes—20 to 900 HP



Choose a Worthington plunger pump . . .

ODDS FAVOR YOU—160:1

Yes, you can choose from 160 standard sizes in the basic Worthington plunger pump line—25 horizontals, 135 verticals. You get 160 chances to be right from our basic pump models. But that isn't all.

In both lines, speeds can be varied, still other plunger and cylinder sizes are available. So each type can be tailored to deliver a very exact performance.

Remember, you choose from two basic types—horizontal or vertical. Each has its basic benefit. The horizontal power pumps have extremely low first cost; the vertical power pumps are designed for extremely rugged, long-life service.

Both vertical and horizontal Worthington power pumps are engineered to give the most reliable possible performance for their type. Stainless steel valves and Colmonoy plungers are typical long-life features.

You'll find both Worthington power pump types are designed for easy maintenance. There is fast access to valves through individual valve covers—piping remains undisturbed. Each cylinder size will accept a choice of plunger diameters to suit service conditions, and other parts are interchangeable between similar models.

Yes, because of the breadth and flexibility of the line, Worthington power pumps can be matched quickly to any power pump installation.

For information, write Worthington Corporation, Dept. 32-12, Harrison, New Jersey. In Canada, Worthington (Canada) Ltd., Brantford, Ontario.

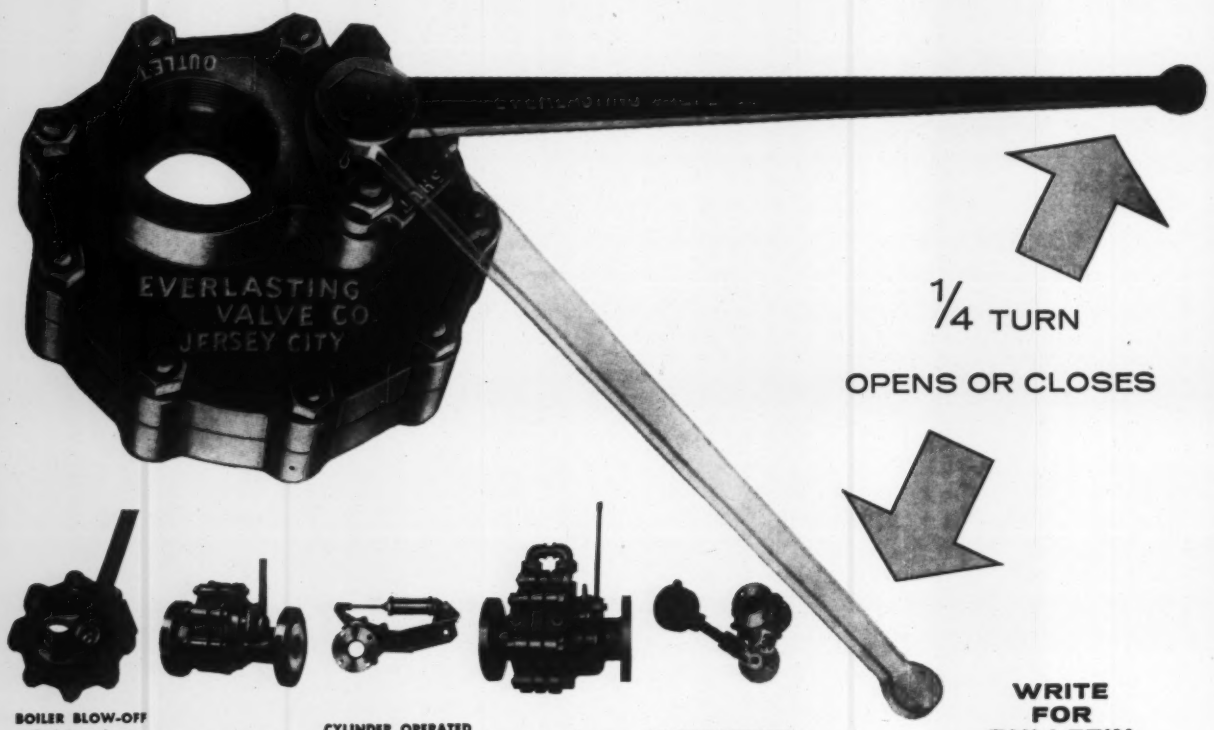
WORTHINGTON

PRODUCTS THAT WORK FOR YOUR PROFIT

Circle No. 141 on Readers' Service Card

When you need fast, easy opening and closing with a leak-proof seal and straight-through flow with minimum pressure drop specify

EVERLASTING



BOILER BLOW-OFF
Quick acting, also handwheel operated "Y" and angle types. For pressures up to 600 psi.

GENERAL SERVICE
Where drop-tight seal and full flow is essential.

CYLINDER OPERATED
Can be remotely controlled, electrically or manually.

STEAM JACKETED
Assures free flow of viscous materials.

WEIGHT-OPERATED
For automatic drains or emergency shut off.

WRITE FOR BULLETIN

EV-409

EVERLASTING VALVE COMPANY, 80 FISK STREET, JERSEY CITY 5, N.J.

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- Designed for rapid, accurate use
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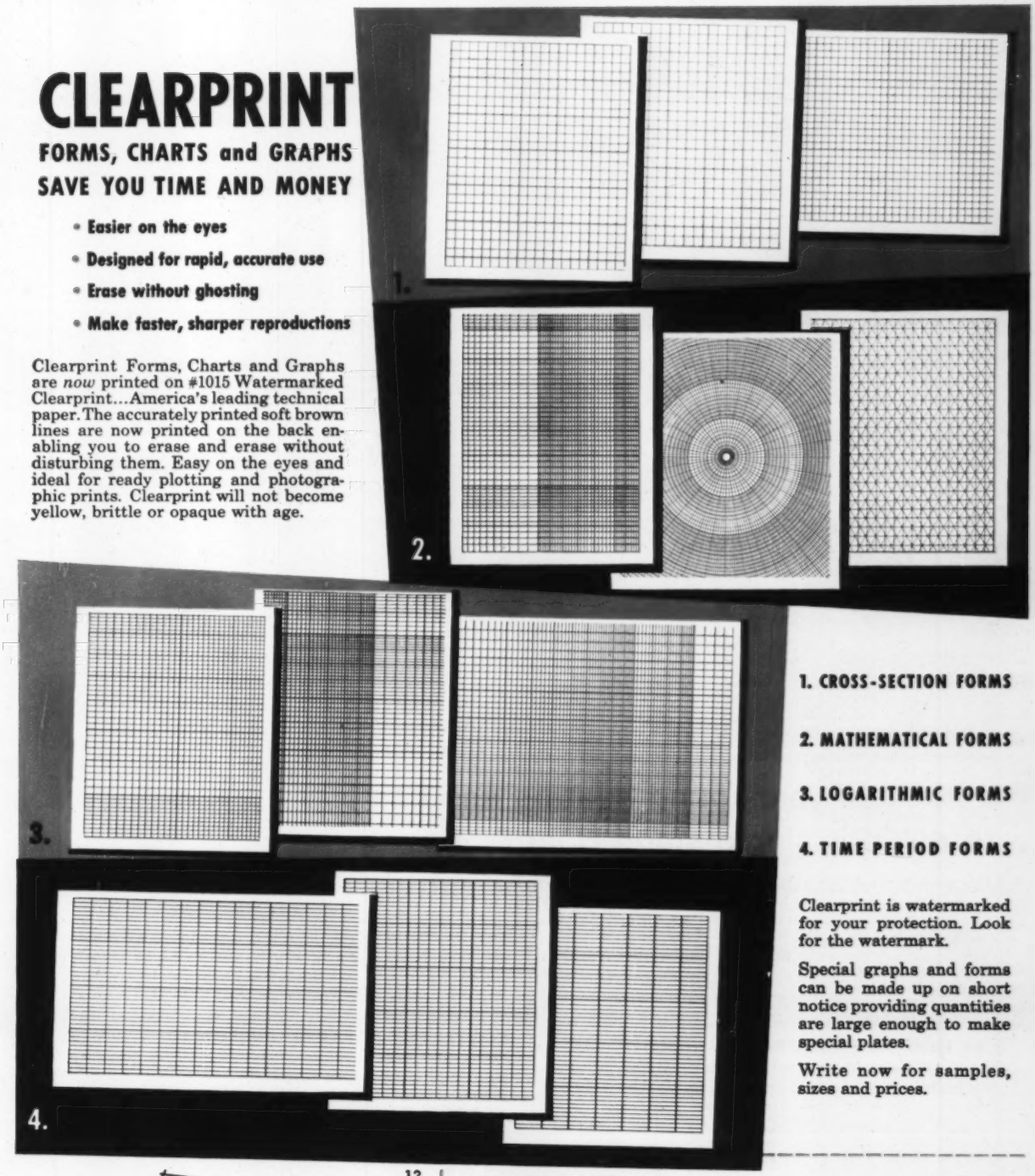
Clearprint Forms, Charts and Graphs are *now* printed on #1015 Watermarked Clearprint...America's leading technical paper. The accurately printed soft brown lines are now printed on the back enabling you to erase and erase without disturbing them. Easy on the eyes and ideal for ready plotting and photographic prints. Clearprint will not become yellow, brittle or opaque with age.



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2. MATHEMATICAL FORMS

3. LOGARITHMIC FORMS

4. TIME PERIOD FORMS

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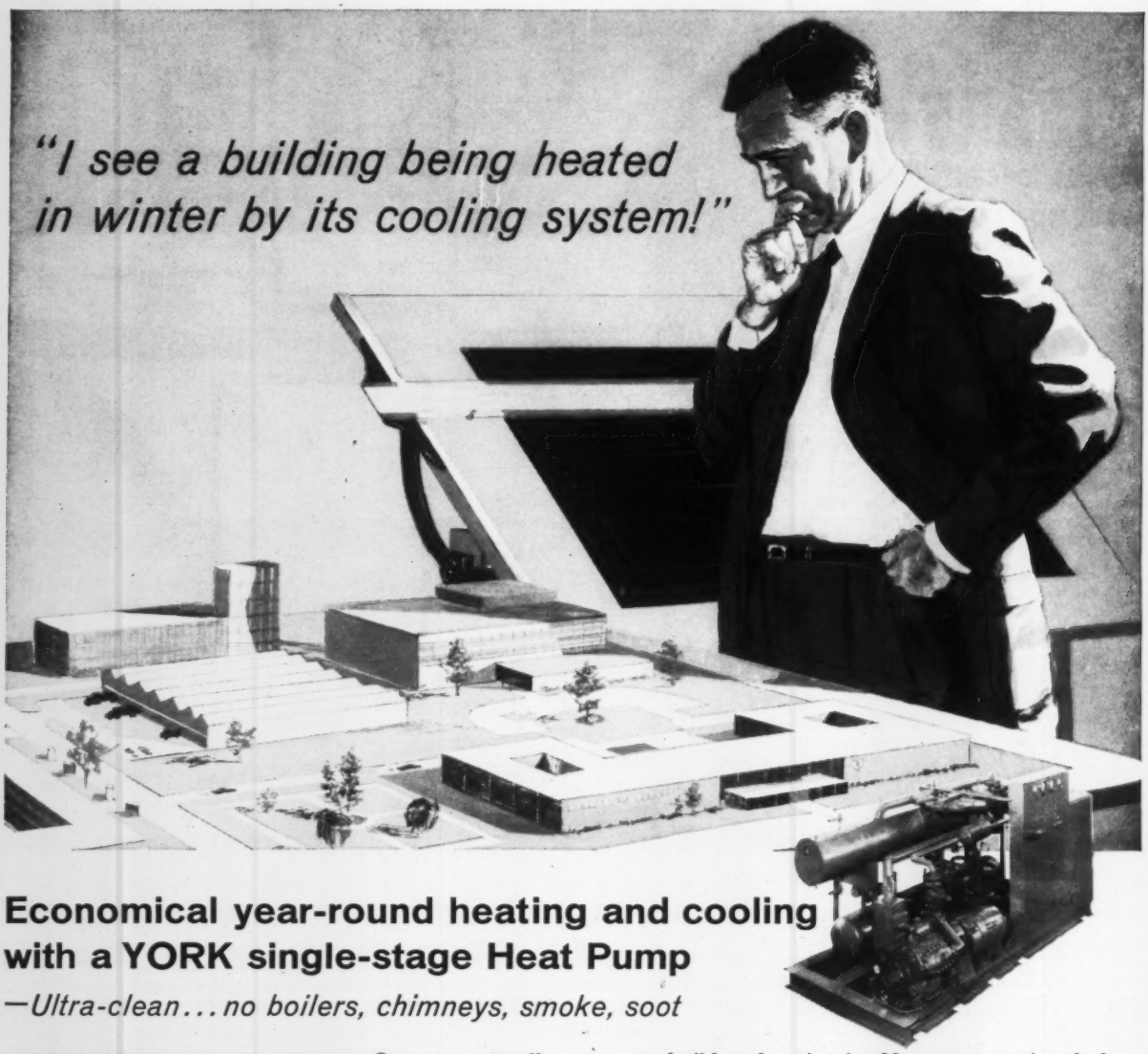

Economical year-round heating and cooling with a YORK single-stage Heat Pump

—Ultra-clean... no boilers, chimneys, smoke, soot

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CAN HEAT AND COOL SIMULTANEOUSLY—Versatile York Heat Pump can take heat from one area of a building needing cooling, and move it to another area needing heat. Can also utilize waste heat from exhaust air, processing, etc.

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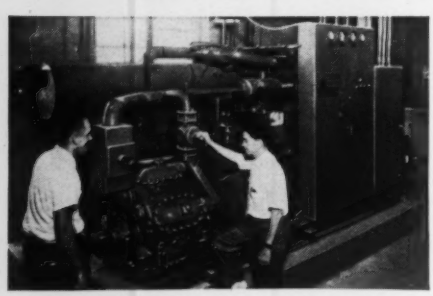

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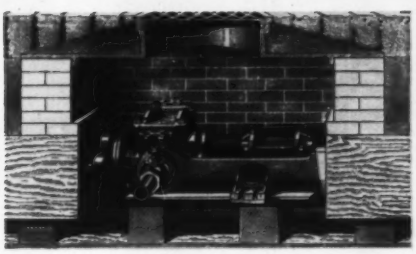

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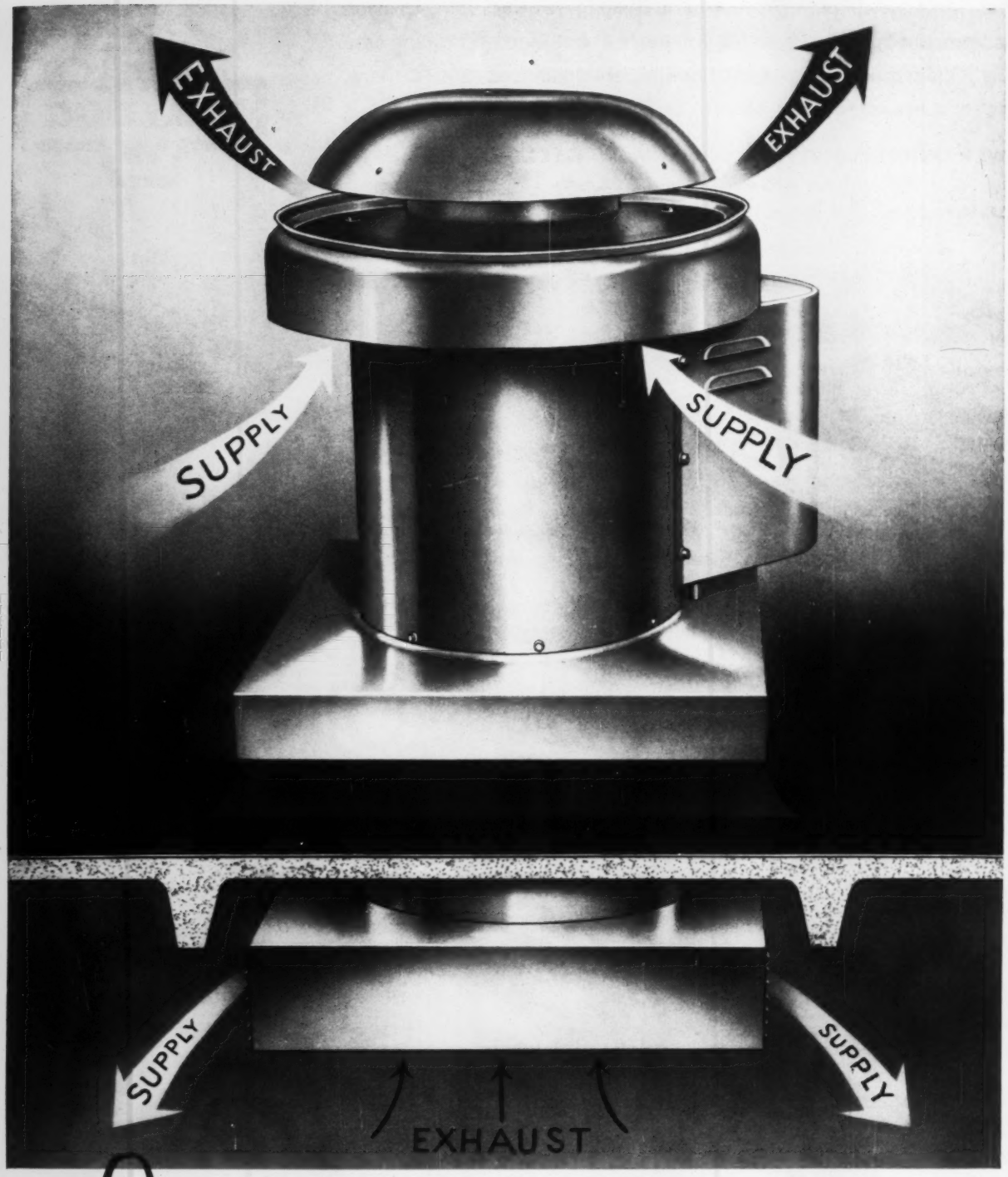

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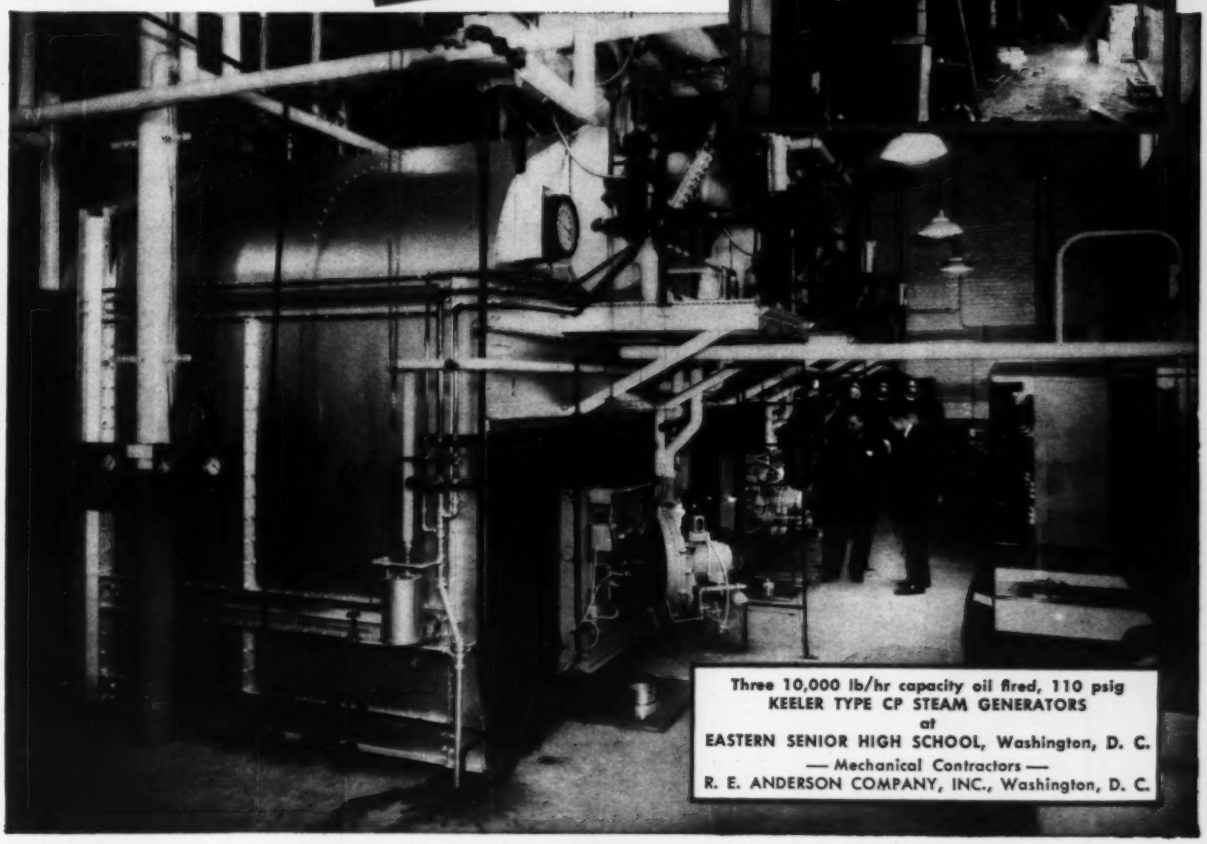

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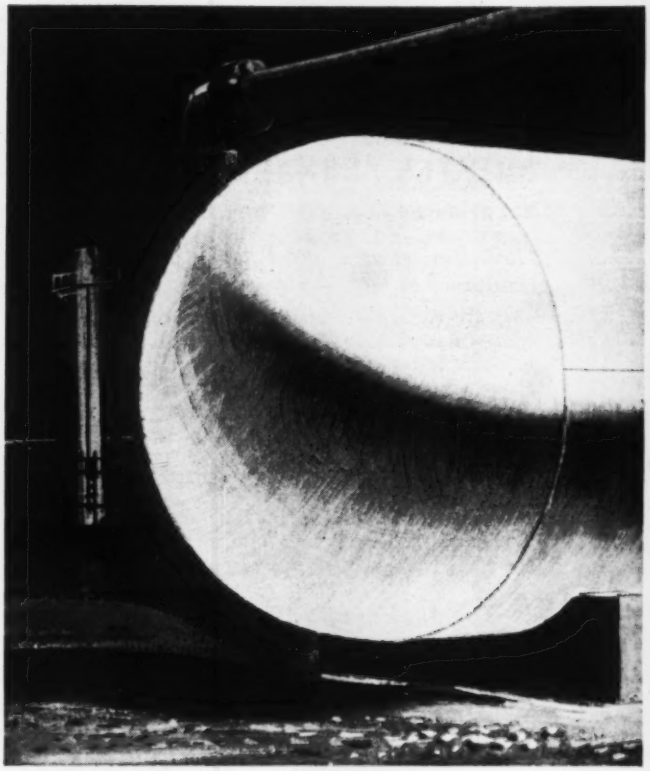

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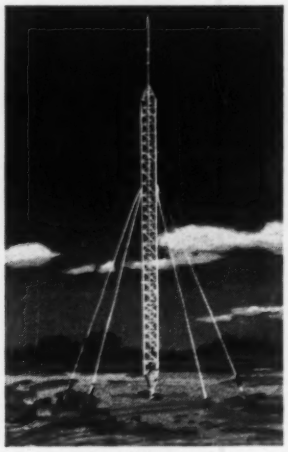

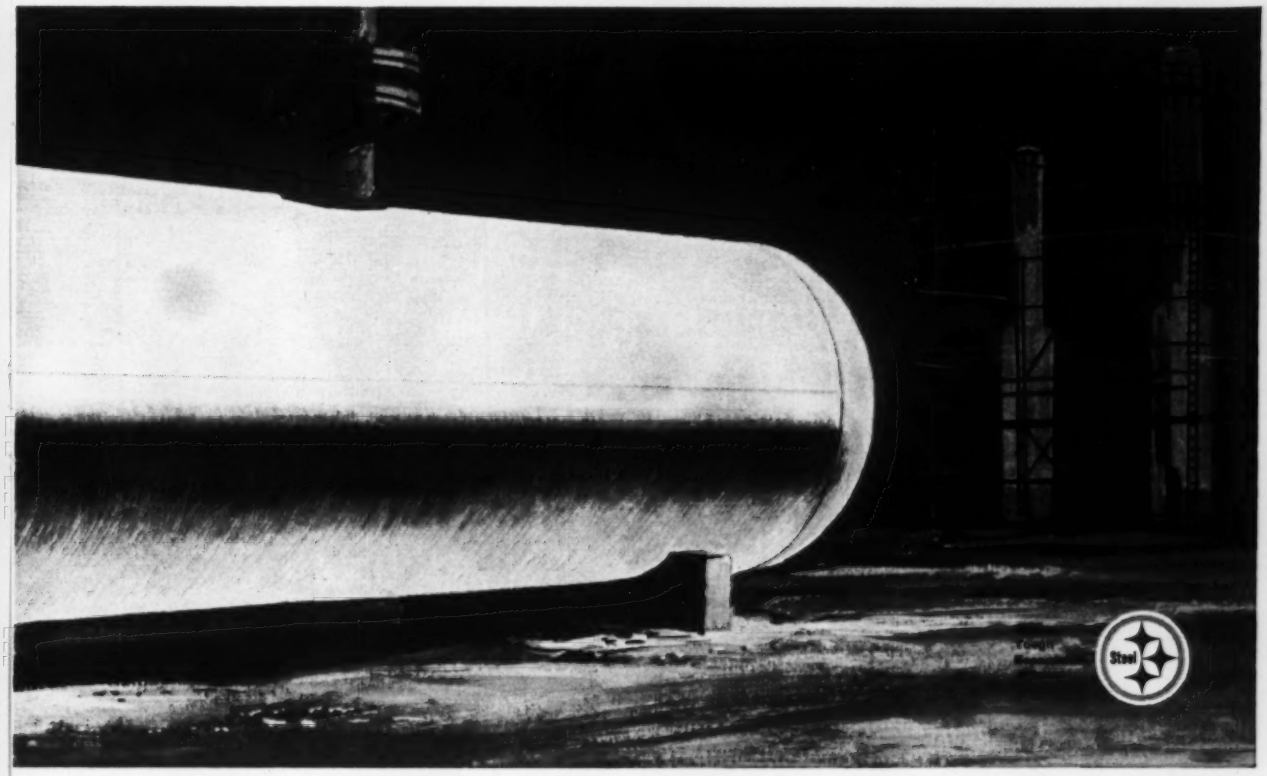

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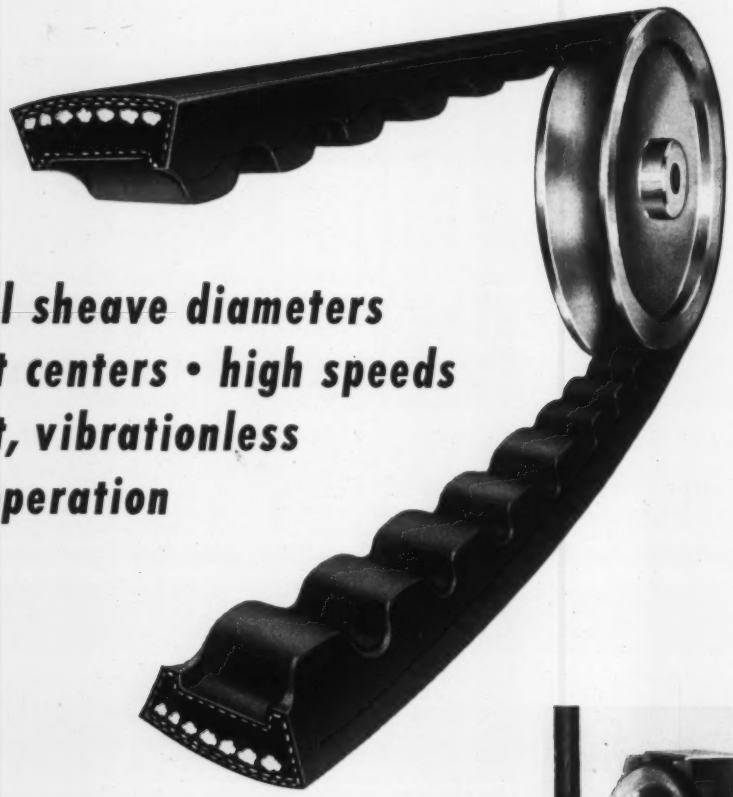

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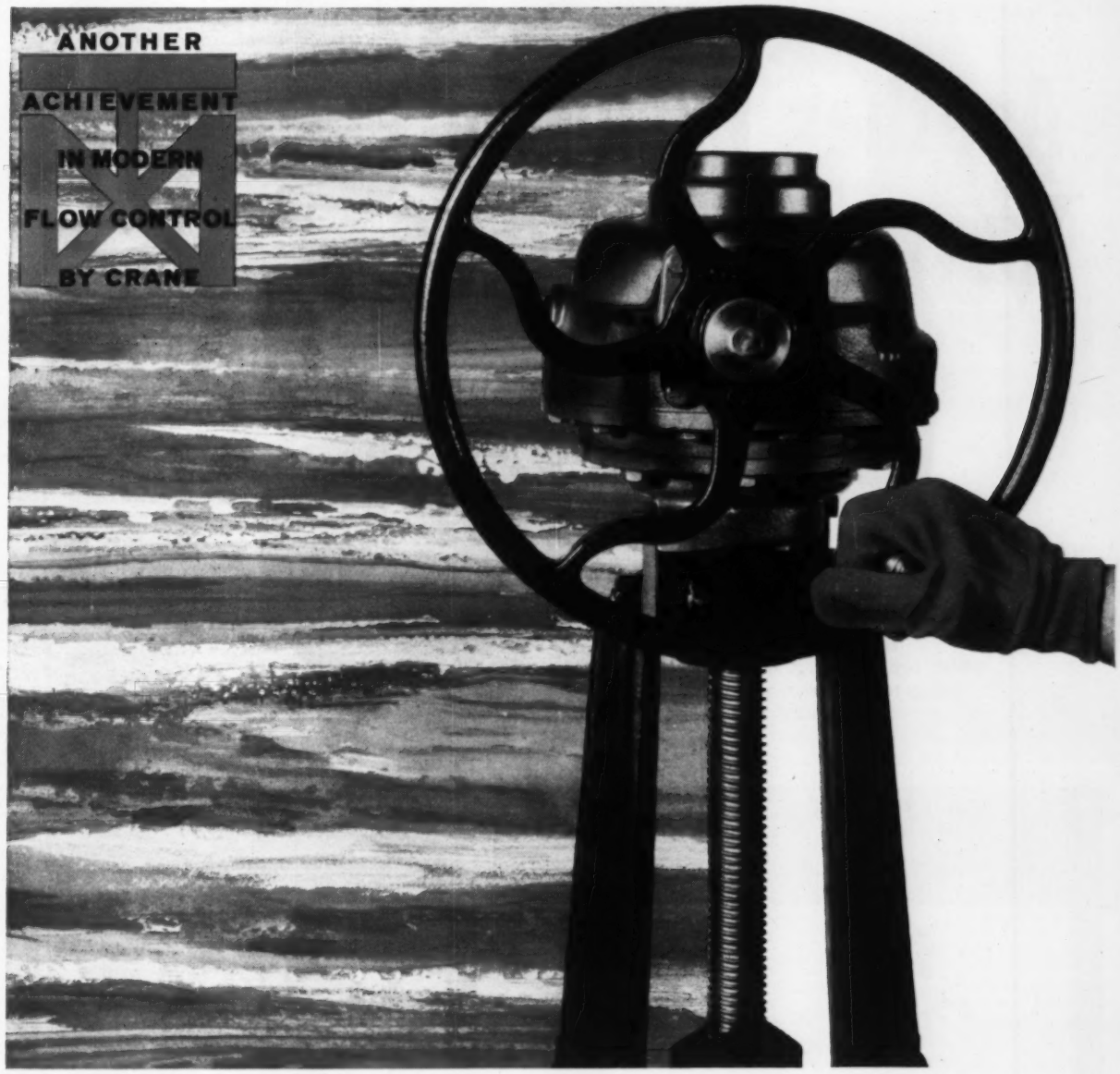

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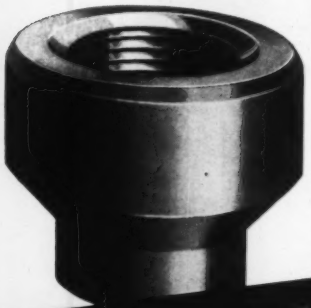
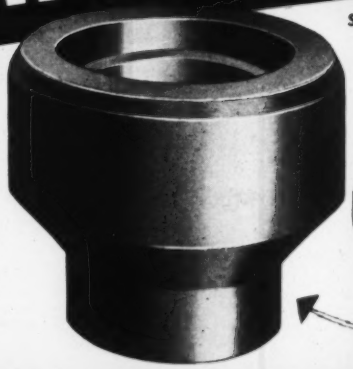


THREADED TYPE



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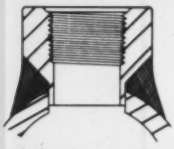
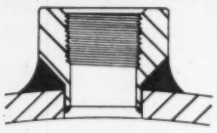
The Vogt Weld Couplet is an easy-to-install fitting for branch connections from pipe, vessels or tanks. It replaces more-difficult-to-install welding bosses, couplings and the type of fittings requiring trimming or matching to fit contour of vessel or pipe.



Small Diameter Pipe



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Vogt Weld Couplets adapt to any pipe or vessel curvature by simply adjusting the height position of the couplet when welding. This characteristic means easy installation, positive positioning and alignment, a stronger weld without distortion, and no inside "icicles" of welding material.

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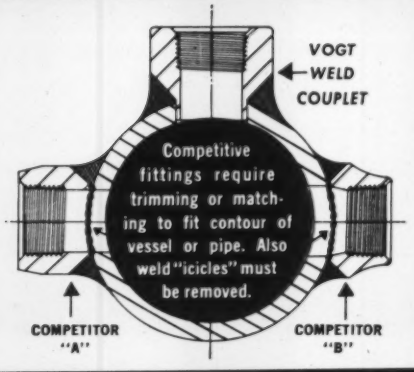
VOGT
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Competitive fittings require trimming or matching to fit contour of vessel or pipe. Also weld "icicles" must be removed.
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MECHANICAL ENGINEERING

VOLUME 83 • NUMBER 5 • MAY, 1961

Design Engineering

WHAT is rapidly becoming a "must combination" for design engineers gets under way once again on May 22, 1961, in Detroit's new Cobo Hall. The "combination" is the ASME Design Engineering Conference and concurrent Design Engineering Show.

With the theme, "Designing for the Competitive Market," the Conference, as usual, will be sponsored by ASME's Machine Design Division. Altogether, 22 major technical papers will be presented in four days of morning sessions, keynoted by an opening-day panel to set the Conference theme. This panel of four top-flight automotive executives will discuss their department roles in designing a superior product to meet our ever-present competition. They will highlight the interplay of production, purchasing, and engineering.

In addition, the Conference's expanded technical program will feature papers by leading authorities in the fields of mechanical and electrical design, materials, systems, and manufacturing.

Every afternoon, the show, now in its sixth year and staged in the Auto Capital for the first time, will present the most recent results produced by the nation's leading research and development laboratories. More than 400 companies will exhibit.

Produced by Clapp & Poliak, Inc., of New York, displays at the exposition will cover seven acres and are valued at more than $10,000,000. And on hand to demonstrate equipment and to answer visitors' questions will be some 4000 experts in the exhibit booths.

Because it covers new developments in all fields, and because the current economic situation has heightened the search for new products, the show should have unusual significance for businessmen this year.

More than 100 companies will show new types of materials. All sorts of mechanical, electrical, and electronic components will be displayed, as well as power-transmission equipment, fasteners and adhesives, finishes and coatings, shapes and forms, and various kinds of engineering accessory equipment and services.

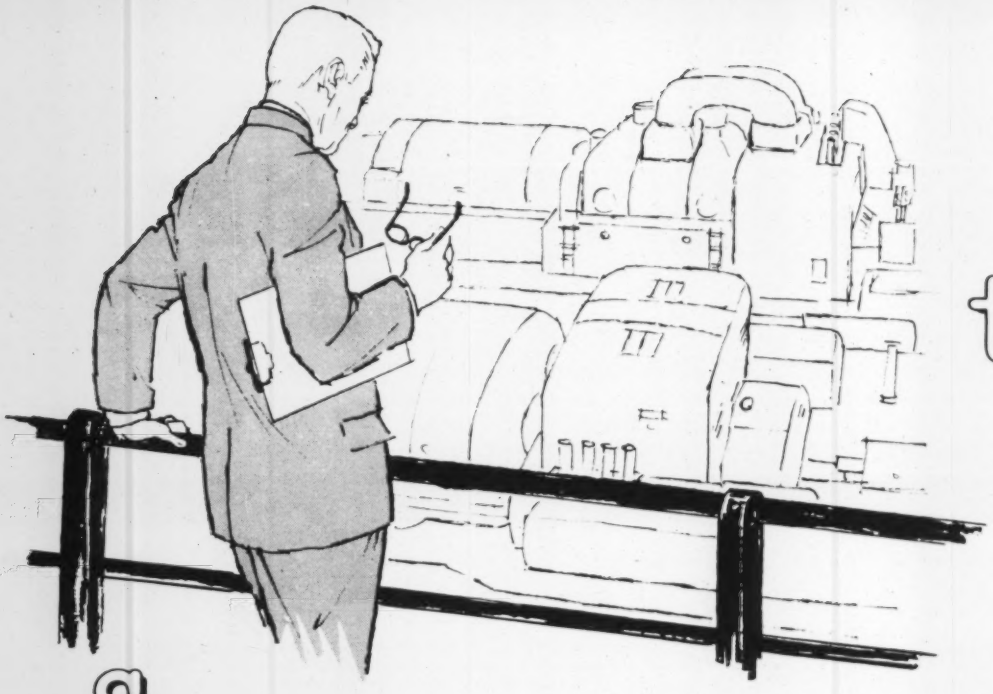
To give our readers some idea of what can be expected at Cobo Hall, MECHANICAL ENGINEERING has prepared this special Design Engineering Issue.

In the feature section, pages 41-55, four of the Conference papers are presented in condensed form. In addition, a special Design Conference and Show insert, pages 149-156, includes the exhibit floor plans, list of exhibitors, program in brief, and digests of the 22 technical papers to be presented at the Conference.

The Conference and Show are ideal partners. Both will offer new design ideas. It has been said that "until design engineering has done its work, purchasing has nothing to buy, production has nothing to manufacture, sales has nothing to sell." The basic role of design engineering is at no other time so fully appreciated as when competition is acute and every company's success depends upon its ability to design superior products that can be sold at lowest possible cost.

The ASME Conference tells you how; the Show gives you the tangible means of achieving the designs you want. So, remember the dates: May 22–25, 1961; the place: Cobo Hall, Detroit, Mich.—*J. J. Jaklitsch, Jr.*

Editor, J. J. JAKLITSCH, JR.



the

Since the engineering profession is in a perpetual state of evolution, the problem of engineering education is never completely solved. This is doubtless why Professor J. H. Keenan[2] and Dean M. P. O'Brien[3] insist, in Mechanical Engineering for June, 1959, that engineering educators must always keep in mind what the engineer is and does.

Engineering, of course, is both science and art, and there are both scientific engineers and artist engineers. The scientific engineer seems to be mainly an analyst, while the artist engineer is mainly a synthesist. The great majority of engineers probably combine science and art in their work, but the two types have to be sharply differentiated in order completely to visualize the structure of the engineering profession.

The advances in the engineering sciences have been so spectacular since World War II that they have completely captured the imagination of engineers and of the public. Many engineers have concentrated on scientific and engineering research and on the concept and elaboration of engineering systems. Their brethren who have translated their research results and systems into useful machines and structures have appeared to be a little to one side of the really important things in their profession.

The scientific engineer is the hero of the moment, and the artist engineer has been forgotten; and so, to a degree, has his education.

Science of Engineering

A scientific engineer, or his employer or client, may feel that it is cumbersome to absorb the sun's energy in the leaves of the trees, to bury that energy in the depths of the earth, and painfully to expend money and labor after millions of years to dig it up in the form of coal or oil. Why not capture the sun's energy as it arrives on the earth's surface? So the scientific engineer may try to conceive solar heat or power applications.

He will study radiation, thermodynamics, heat transfer, metallurgy, meteorology, fluid flow, and the like. He will experiment and compute, and he hopes to come up with a schematic diagram, or a system, for solar heat.

Usually he does not like to proceed beyond the schematic-diagram stage of the business. He contends that development, design, tooling, production, testing, redesign, economic analysis, costing, selling, and servicing do not concern him. He expects others to perform these tasks. Although he does indeed serve the public indirectly, the scientific engineer thinks much more about radiation theories than he thinks about the customers who will ultimately purchase the solar apparatus.

The Artist Engineer

At the schematic-diagram stage the artist engineer takes over. His particular job is to produce a solar apparatus which will serve a purpose; it must provide a utility. The solar-heat device must heat a building, or some machine or equipment, more adequately than the building or machine has been heated before; or more conveniently, or at lower cost. Or it may do all three. If it does none of these it is quite futile, no matter how beautiful the design or how ingenious the concept.

The artist engineer, or several of them working together, has to assume entire responsibility for the solar project. He must pick up the job when the scientific engineer has delivered the schematic diagram and has washed his hands of the matter. He must guide the project through all of its precarious and baffling progress until a usable apparatus is delivered to the customer at a reasonable cost, and until the customer is fully satisfied.

The artist engineer has to experiment and develop. He has to evolve a design for the solar apparatus that will function successfully, which can be produced with the available or procurable plant and production equipment, and which can be easily installed, serviced, and repaired.

---

[1] Dean, College of Engineering, University of Detroit, Detroit, Mich.

[2] J. H. Keenan, "Education in Transition," Mechanical Engineering, vol. 81, June, 1959, pp. 76–78.

[3] M. P. O'Brien, "The Profession of Mechanical Engineering," Mechanical Engineering, vol. 81, June, 1959, pp. 74–76.

Presented under the auspices of the National Committee of Engineering Department Heads at the Winter Annual Meeting, New York, N. Y., November 27–December 2, 1960, of The American Society of Mechanical Engineers.

"artist" engineer

By Clement J. Freund,[1] Fellow ASME, University of Detroit, Detroit, Mich.

The engineering world needs to become oriented toward the artist engineer — the man who brings the dreams of the scientist to reality, the designer and producer of hardware

He must provide and adapt machines and attachments; he must see to tooling; he must get his components assembled and the assembly tested. Later he must sell the apparatus, or he must instruct and direct the engineer or salesman who does. He must create and maintain a staff to service the solar apparatus in customers' hands.

Throughout all this he must study solar energy and all the technologies which pertain to it. At frequent intervals he has to go back to the scientific engineer to find out if any new research data have made his design obsolete.

Since no one artist engineer can do all of this, a number of artist engineers must work together, and there must be co-ordination and division of labor. At least one of them must know how to organize and administer, and how to solve all the many and difficult problems which arise the moment two or more persons try to dovetail their efforts.

When Vannevar Bush spoke before the American Engineering Council on the "Qualities of a Profession," he described the art of engineering as "ministry to the people."

Whenever people discuss engineering application, it is apparently assumed to mean rule of thumb and the application of outmoded and old-fashioned scientific information. Talk to an engineer or an engineering educator about the art of engineering, and he will probably reply, either innocently or caustically, "Oh, you mean welding, or pattern making, or testing for carbon—that sort of thing."

It should be explained that the art of engineering in the present discussion means something quite different. The art of engineering in this discussion is the use of the most up-to-date scientific resources to devise machines and structures by the most modern methods for the use of the people—ministry to the people, as Bush calls it.

Qualifications of the Artist Engineer

The artist engineer must, of course, possess all those qualifications which are required of every engineer; they have been enumerated and described over and over. But what special characteristics must the artist engineer have in order to succeed in his peculiar vocation? He must be familiar with the most modern engineering materials, and he must know about the submolecular and internal science of materials. He must be strong in thermodynamics, radiation, heat exchange, reflection, fluid flow, and other technologies which pertain to his solar project.

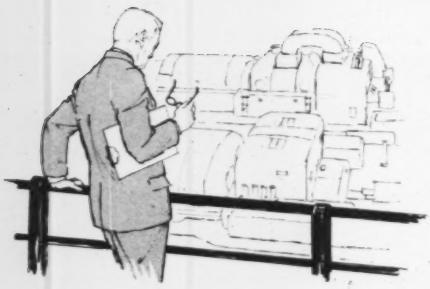
He has to be curious about research and research results, and must keep himself informed about them. He must know at least enough about them to understand the scientific engineer when he is talking to him. He certainly must know how to organize and operate a test or an experiment. But he need not be a competent researcher. He can leave that to the scientist.

He has to be informed about the procurement and supply of steel, alloys, and other materials which go into his solar apparatus. He must know about founding, forging, pressing, stamping, machining, welding, and assembly; and he must know about current improvements and developments in all these processes. He must use electronic, magnetic, numerical, and other devices for the automatic control of processes and operations, and of quality.

He must have a dominant sense of practical economics; he must never forget that the solar apparatus must be sold for more than the total cost of making it; and that the customer must want the apparatus more than the money he has to pay for it.

More important, perhaps, than all of these, he has to have a special kind of intuitive judgment to make decisions when he can't get all the precise technical data he ought to have. And what artist engineer has ever had all the facts and figures he wanted? He must know how to extrapolate beyond his computations, and his research and test results. The scientific engineer needs that kind of judgment, too, but he only speculates in advance of his experiments, while the artist engineer has to spend money out there, often lots of it, and almost always somebody else's.

This is a formidable set of qualifications when they are set out on paper. The first impulse is to protest that no such engineer is actually alive or ever has been. But this is a composite picture of a number of men who work



together. Besides, one may actually meet engineers who very nearly, if not fully, measure up to these specifications. These men are less spectacular and dramatic in themselves than is the account of their qualifications.

In spite of their competence and achievements, artist engineers have not succeeded in making their fellow engineers and the public appreciate them. The scientific engineers have done a much better job of public relations; or have had it done for them. They are the glamour corps of the profession. Newspapers, magazines, technical journals, motion pictures, radio, and television have told how they have made over the face of the earth and have opened up amazing prospects for a better and even a happier world. The scientific engineer is represented to the people as the wonder worker of the new era.

On the other hand, the artist engineer is made to appear as a mere assistant to the scientific engineer, his servant or helpmate, a sort of noncommissioned officer. The commanding and resourceful artist engineer who undertakes giant projects for power, processing, or manufacturing is no longer a hero. The remust be Goethalses and Westinghouses in the world today but the public doesn't want to know about them. Apparently many engineers don't, either. The scientific engineer, who is considered introspective and impractical, has won popular acclaim, while the artist engineer who works with the people and is thought to understand them has made no impression at all.

The Task of the Colleges

A balance of dignity and status between the two types of engineers should be restored. Otherwise there will be no strong and able men to bridge the gap between the scientific engineer with his schematic diagram for solar apparatus, and the toolmaker and production foreman who must get the apparatus through the manufacturing plant.

It is up to the colleges to educate young men for the artist phase of the profession as well as the science phase. To do so is not fashionable at the moment. It is not here proposed to relax the present emphasis on engineering sciences in the colleges, and to substitute emphasis on applications. The colleges must do both. They must prepare the scientific engineer as well as they have since World War II, and in addition they must prepare the artist engineer. Most especially, they must give equal recognition and status to both.

If the engineering faculties fail to stress engineering applications (art) they may eliminate themselves. It is not clear that engineering sciences are sufficiently distinct from physics and chemistry to justify separate institutions and facilities. If the colleges and universities neglect engineering art in these days of the appalling cost of higher education, trustees may decide to dismantle the colleges of engineering and to transfer the departments of engineering science to the colleges of liberal arts and the graduate schools. Something like it has already been done in one of our major universities and is apparently proposed in others.

How shall the colleges both enhance the prestige of the artist engineer and educate him for his role in the profession and in industry? The answer to this question requires another paper, or other papers. But a few suggestions will be appropriate, lest it be said that it is easier to describe a difficulty in engineering education than to propose solutions of the difficulty.

For one thing, the faculties must extol the artist engineer. Administrators and teachers must make it clear to students that the artist engineer, the applications man, is in every sense the equal of the scientific engineer, and that the contribution of the one is as valuable as that of the other. More importantly, they must point out to the students that the artist engineer is more directly concerned than the scientific engineer with the proper function of the profession, which is "ministry to the people."

The engineering educators will have to do all this without in the slightest belittling the scientific engineer. They must keep the scientific engineer up on his pedestal, but they must erect a pedestal of equal height for the artist engineer.

The artist-engineering student must have particularly effective instruction in the humanistic-social phase of the curriculum. Perhaps a scientific engineer can carry on with limited human contacts, mainly with those who work with him and who can understand him. But the artist engineer must possess a vivid and sympathetic understanding of the entire community, and of all the individuals who comprise that community, from the noblest and the most intelligent down to the base and the ignorant.

The artist-engineering student has to become customer conscious rather than merely user conscious. The teacher must ask him such questions as: Can the solar apparatus be readily manufactured? Does anybody really need or want it? Will it pay to produce and to sell it? He may not be able to answer these questions. Indeed, experienced engineers often can't. But he should try; or at least he should know that the questions must be answered.

The conference at the Worcester Polytechnic Institute last December determined that the student must be required "to exercise a high degree of originality and independence of thought."[4] It might be added that his independent thought should be addressed to the needs of the people; specifically, the customer.

To Correct an American Deficiency

If engineering is to come fully into its own as a profession, engineers and the public will have to take the artist engineer more seriously. If educators don't produce more artist engineers, the nation will end up with a population of brilliant scientists, and libraries full of research reports, but nobody who can put these reports to use A Detroit manufacturer makes chasses for satellites. He has witnessed many an American fizzle at Cape Canaveral. He has declared in public that, as far as he can make out, the satellites have not failed because American science is deficient; they have failed because American engineering arts are inferior to Russian engineering arts.

[4] "Conditions Conducive to Originality Needed to Speed Research, Say Authorities," MECHANICAL ENGINEERING, vol. 82, March, 1960, p. 117.

DESIGN ENGINEERING '61

The machine designer faces competition that demands the ultimate in creative engineering. Here, in condensed form, are four of the papers to be presented at this year's Design Engineering Conference and Show to be held in Cobo Hall in Detroit, Mich., May 22-25, 1961.

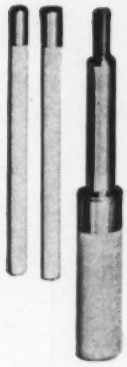
1. GLASS AND CERAMICS in Machine Design ..... J. R. Blizard

2. WHICH DRIVE — Electric, Mechanical, or Hydraulic? ..... G. W. Younkin

3. PRODUCIBILITY — Designing for Production ..... C. E. Warner and R. L. Berg

4. ADHESIVES for the Bonding of Metals ..... H. R. Butzlaff and K. F. Charter

DESIGN ENGINEERING '61



Strength, thermal durability, dimensional stability, and abrasion resistance —these qualities give glass and ceramics a high potential for use in machine parts

By J. R. Blizard, Mem. ASME,
Corning Glass Works, Corning, N. Y.

GLASS AND CERAMICS in

CERAMICS' POTENTIAL in mechanical and structural applications has been barely uncovered. This potential will not be realized fully until the product designer understands the capabilities and limitations of these materials. Used properly, they offer strength, thermal durability, dimensional stability, abrasion resistanee, and many other desirable properties.

The mechanical characteristics differ widely from those of metals and are therefore often misunderstood. Brittleness, of course, is the most important distinction between the ceramics and metals. A ceramic material does not plastically flow or creep before failure. It breaks in pure tension; never in shear and only rarely in compression.

Metals, being ductile, can deform plastically to relieve local stress concentrations. The ceramics, on the other hand, are too stiff to yield and as a result are greatly affected by stress raisers, especially those occurring at the surface. A glass rod with virgin surfaces will support a stress of 100,000 psi, but the same piece with sand-blasted surfaces will hold only a tiny fraction of the original stress.

Contributed by the Machine Design Division for presentation at the Design Engineering Conference and Show, Detroit, Mich., May 22–25, 1961, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Condensed from Paper No. 61—MD-6.

Points of Design

In designing load-bearing ceramic parts, it is well to bear these points in mind:

Apply the load in compression if possible.

Use simple shapes. Avoid sharp corners, sudden changes of section, holes in tension zones.

Keep ground or abraded surfaces out of tension unless they are given a fine smooth finish.

Contact zones with metal parts should be padded with resilient materials if they are to be load bearing.

Avoid point loading and stress concentrations.

Thermal-expansion coefficients of ceramics generally are much lower than for metals. It is thus important to allow for mismatches in ceramic-metal assemblies for hot service. Where clearances are tight, the metal part can be made thin enough so it deforms instead of overstressing the ceramic. If the metal piece clamps and compresses the ceramic, the dangers of overstressing are also greatly reduced.

The thermal endurance of a ceramic part is potentially

Table 1 Typical Properties, Bonded Ceramics

		Alumina			Beryllia	Steatite	Forsterite	Silicon Carbide	
Property	Units	85% Al_2O_3	96% Al_2O_3	99% Al_2O_3	96% BeO	$MgSiO_3$	Mg_2SiO_4	Silicious bond SiC	Silicon nitride bond SiC
Tensile strength[a]	Psi	43,000	48,000	60,000	32,000	20,000	20,000	2000[b]	5600[b]
Modulus of elasticity	10^6 psi	32	42	50	46	14	14	17	17
Hardness—Moh scale		9	9	9	9	7.5	7.5	9.6	9.6
Max working temp	F	2550	3100	3140	2200	1800	1800	2750	3000
Thermal expansion coefficient 72-750 F	In/in/F ($\times 10^{-7}$)	35.0	40.0	40.0	51.0	46.0	55.0	24.5	24.5
Thermal conductivity 72 F	Btu/hr sq ft F/ft	8.0	12.0	17.0	157.0	1.4	1.4	8.5	8.8
Specific gravity		3.40	3.72	3.90	2.90	2.6	2.8	2.57	2.87
Water absorption	Per cent	Nil	Nil	Nil	Nil	0 to 0.02	0 to 0.02	13	8

[a] Measured in flexure (modulus of rupture). [b] At 2500 F.

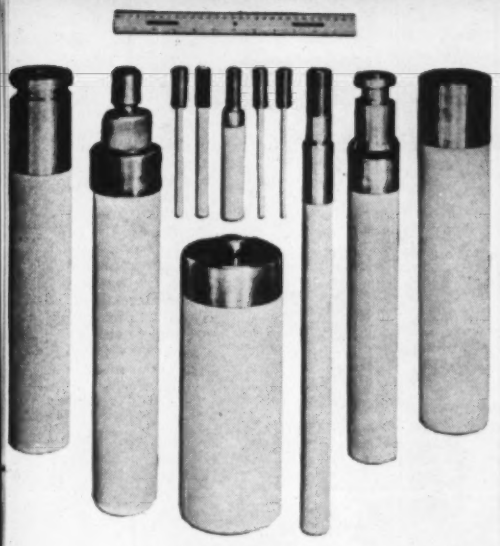


Fig. 1 Pump plungers made of high-alumina ceramics. They are for abrasive liquids and slurries. The metal adapters are cemented to the alumina with an epoxy adhesive. *(Courtesy Coors Porcelain Co.)*

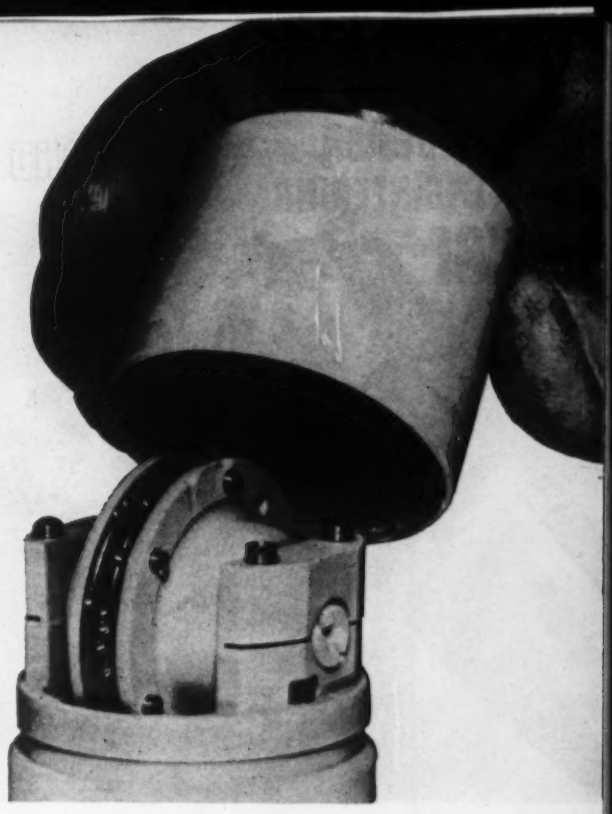


Fig. 2 A ceramic gyroscope assembly. Gyroscope parts were molded from powder, rough finished before hand firing, and brought to size by diamond-wheel grinding. Dimensions were held to 0.000005 in. *(Courtesy Minneapolis-Honeywell Regulator Co.)*

Machine Design

high—much higher than metals. Failure is unlikely, within the recommended operating limits, unless the part is subjected to excessive thermal stresses. These may be steady state, as in a hot wall, or transient stresses resulting from sudden heating or cooling.

All thermal stresses can be minimized in the following ways:

Choose a ceramic with low thermal expansion.

Use thin sections.

Reduce mechanical constraint to a minimum. Let the part "float" if possible.

Avoid localized hot or cold areas in the part. Expose the entire ceramic area to heat rather than shrouding the edges.

Certain ceramics, like fused silica, 96 per cent silica glasses, and glass-ceramic No. 9608, have such low expansion coefficients that they are practically immune to thermal shock failure.

Designing a complex ceramic shape for service under mechanical or thermal stress is far from an exact science. The effects of surface and shape cannot always be predicted and it is highly advisable to submit these problems to the materials supplier. In certain cases it may be necessary to test preproduction samples.

For the Product Designer

There are certain ceramic materials whose properties and availability make them of special interest to the product designer. Their mechanical properties are listed in Table 1.

High-alumina ceramics can be compared to the high-alloy steels in the metal family. They are made in various purities, mainly 85, 96, and 99 per cent Al_2O_3. Their mechanical properties are among the best in the ceramic group and, although they are relatively expensive, they are used generally when it is necessary to have exceptional strength, abrasion resistance, heat resistance, or chemical purity. Their mechanical applications include metal-cutting tools, sandblast nozzles, pump plungers, seal rings, and ball check valves. Fig. 1 illustrates pump plungers.

An instrument manufacturer has developed a gyroscope made from an alumina ceramic for use in missile guidance systems. In this application, the ceramic provides high elastic modulus, dimensional stability, heat resistance, corrosion resistance, and has the ability to be finished to extremely fine tolerances (Fig. 2).

Beryllia, BeO, is one of the newest ceramic materials. As may be expected, its cost today is much higher than the other ceramics, being from 3 to 7 times as expensive as

Table 2 Typical Properties, Glassy Materials and Glass-Ceramics

		Glasses					Glass–Ceramic	
Property	Units	Lime 0281	Lead 0120	Borosilicate 7740	96% Silica 7900	Fused silica	(Pyroceram) 9606	9608
Tensile strength[a]	Psi	7000	7000	8000	8000	8000	20,000	20,000
Modulus of elasticity	10^6 psi	10.0	8.2	9.5	9.6	10.4	17.3	12.5
Hardness—Knoop		470	400	470	500	550	700	700
Max working temp	F	500	500	700	1800	1800	1300	1300
Thermal expansion coefficient	In/in/F × 10^{-7}	48	49	18	4	3	32	8
Thermal conductivity 72 F	Btu/hr sq ft F/ft	0.6	0.4	0.6	0.8	0.8	2.0	1.0
Specific gravity		2.48	3.05	2.23	2.18	2.20	2.61	2.50
Water absorption		0	0	0	0	0	0	0
Transparency or color		Clear	Clear	Clear	Clear	Clear	White opaque	White opaque

[a] Measured in flexure (modulus of rupture).

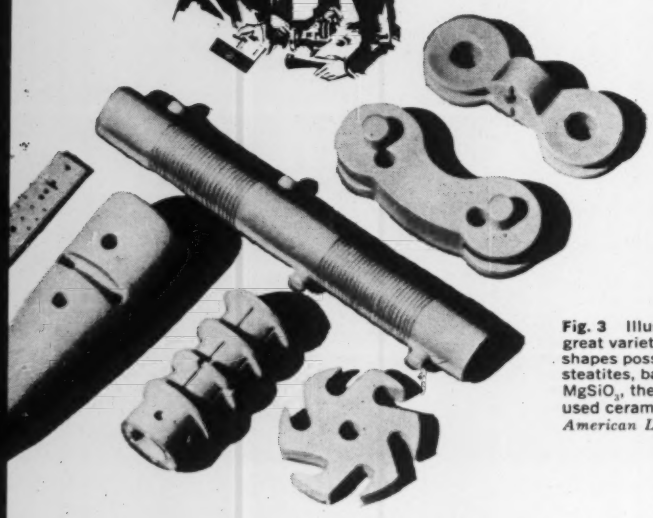


Fig. 3 Illustrating the great variety of complex shapes possible with the steatites, based on $MgSiO_3$, the most commonly used ceramics. (*Courtesy American Lava Corp.*)

Fig. 4 A glass capsule to carry an explosive charge into an oil well. Glass capsules of this type can resist external pressures beyond 30,000 psi without leaking at the cemented joint. When destroyed, the glass pulverizes into fine particles which will not plug orifices or valves. (*Courtesy Corning Glass Works*)

Fig. 5 Right, The high compressive strength of glass allows a window to be hot-molded into the fitting. On cooling, the brass fitting contracts around the window, reinforcing as well as making a seal. (*Courtesy Corning Glass Works*)

alumina. Besides being hard, dense, and thermally resistant like alumina, beryllia has surprisingly high thermal conductivity. At room temperature it is higher than aluminum metal and about 10 times higher than alumina. The advantage is lessened at elevated temperatures, but even at 1000 F, beryllia exceeds alumina by a factor of 6.

Applications for beryllia are presently limited by cost and size restrictions. In most cases the piece will be limited to a diameter of about 4 in. and a height of 8 in. to 10 in. Extruded sections can be made in diameters up to 1 in. and lengths up to 24 in. One of its principal uses is in electronic equipment where it performs the dual function of barring the flow of electricity while permitting the rapid dissipation of heat.

Routine Applications

Other ceramics, at much lower cost, can fill routine needs.

The steatites, based on the composition $MgSiO_3$, are the most commonly used ceramics for low-cost molded parts such as small appliance insulators, heater-wire supports, and tube sockets (Fig. 3). They can easily be machined in the unfired state. Tapped holes and threaded exteriors are feasible.

There are many varieties of steatite and its close relative, forsterite. Table 1 indicates the range of mechanical properties that can be expected.

Alumina, beryllia, and steatite can all be metallized with a tightly adhering film to which metal parts can be soft or hard soldered. Bond strengths of 3500 psi are attained easily, and with special procedures it is possible to make bonds to alumina and beryllia that will withstand loads of 12,000 psi. These latter coatings can be brazed at 1000 C.

Silicon carbide is not usually thought of as a ceramic, but it properly belongs in the category from the standpoint of the design engineer. Long known as an abrasive grain and refractory, silicon-carbide grain is now molded into complex mechanical parts and bonded either with a silicious material or with silicon nitride. The product lends itself to the manufacture of such items as nozzles, pump impellers, pipe fittings, wire guides, and textile-sizing rollers.

Typical properties of silicon-nitride-bonded silicon carbide are listed in Table 1.

Note that thermal conductivity of silicon carbides is high—about the same or slightly less than for the aluminas but much higher than the steatites or glasses.

Molten aluminum, copper, and silver do not wet silicon-nitride-bonded silicon carbides and as a result they are used in melting and die-casting equipment.

A new material, titanium di-boride (TiB_2), with most interesting properties, has just been announced and it is being mentioned here even though it is not yet in general commercial use. Extremely temperature resistant, it can support a 35,000-psi tensile stress at 3600 F. Its elastic modulus is twice that of steel and its hardness is considerably greater than alumina. It is an excellent electrical conductor and has thermal conductivity about equal to alumina. Like silicon carbide, it is inert to molten aluminum and zinc.

Titanium di-boride is molded from powder and can be machined before final processing. The largest pieces made to date are cylinders 6 in. in diam and 20 in. long weighing 100 lb each, and cylinders 14 in. in diam and 10 in. long weighing 260 lb each.

Glass and Glass Ceramics

Heretofore we have been discussing bonded ceramics—materials consisting of small particles bonded together to form a solid piece. The following discussion pertains

Fig. 6 A telescope mirror blank made from fused silica. The parabolic shape is so accurate that the instrument will have resolving power of 1/10 of a second of arc. This compares with ability to distinguish two golf balls 15 in. apart at a distance of 500 miles. (*Courtesy Perkin Elmer Corp.*)

to glasses and glass-ceramics, materials which are very different in structure but which keep the essential mechanical characteristics of the bonded ceramics.

Six glasses or glassy materials will be discussed—lime, lead, borosilicate, 96 per cent silica glasses, fused silica, and the glass-ceramics (or Pyroceram materials).

Lime and lead glasses are well known for use in bottles, electric-light bulbs, spectacles, and tableware. Their properties are listed in Table 2 with those of the other glasses.

Borosilicate glass is familiar through its use in baking dishes, laboratory glassware, boiler gage glasses, and glass piping for chemical plants and dairies. This glass is distinguished by its low thermal-expansion coefficient, about $^1/_4$ to $^1/_5$ that of most metals and $^1/_3$ that of the lime and lead glasses, and by its hard surface and excellent chemical durability.

The 96 per cent silica glasses are melted and formed as conventional glasses and are then converted by chemical leaching and heat-treatment to their final state. Known by the trademark Vycor, they are colorless and very similar to fused silica. Thermal-expansion coefficient of Vycor glass is so low (about $^1/_{10}$ that of lime glasses and $^1/_4$ that of the borosilicates) that they are virtually immune to thermal-shock damage. Heat resistance of 96 per cent silica glasses is much higher than for any other glasses, and they can be used continuously at temperatures of 1600 F, and under some conditions as high as 2000 F. These glasses have exceptionally good ultraviolet and infrared transmission, and will transmit well through the range from 250 to 3000 mu.

There are few limitations on the shapes and sizes that can be produced from 96 per cent silica glassware. It can be made in practically any form in which the conventional glasses are available. Thickness is usually limited to $^3/_8$ in. because of conversion cost, but when necessary it is possible to produce 1-in. slabs. Cost is much higher than that of the borosilicate glasses. Therefore it is used only for unusually severe requirements in heat resistance, light transmission, or dimensional stability.

It has been noted that all the ceramics have high compressive strength. Fig. 4 shows a glass capsule that carries an explosive perforating charge into an oil well. It must resist crushing loads of over 10,000 psi before it is destroyed. When destroyed, the glass pulverizes into particles so fine that they are carried out in the oil stream without plugging orifices or valves.

The high compressive strength of glass allows a window to be hot molded into the sight glass fitting shown in Fig. 5. On cooling to room temperature, the brass fitting contracts around the window, reinforcing and strengthening it as well as making an excellent seal. This unit can be used at pressures of 1000 psi.

Fused silica (also called fused quartz) is essentially pure SiO_2 in an amorphous, noncrystalline form. It may be crystal clear, like high quality glasses, or it may be furnished in a translucent glossy white form at a lower cost.

Tubes, cylinders, rods, laboratory flasks, and ingots up to about 20 in. in diam are made by fusing pure quartz crystals or silica sand. Another process, based on the synthesis of SiO_2, is used to produce slabs and ingots of pure clear silica in sizes ranging upward to 12 in. thick and 60 in. in diam. Fig. 6 shows a telescope mirror blank made from this material. The ultra low expansion coefficient of this material makes it possible to obtain amazingly accurate surfaces. The solid blank has been finished to a true parabolic shape with such accuracy that the instrument will have resolving power of $^1/_{10}$ of a second of arc. This compares with ability to distinguish two golf balls 15 in. apart at a distance of 500 miles.

DESIGN ENGINEERING '61

By G. W. Younkin,[1]

Giddings & Lewis Machine Tool Company, Fond du Lac, Wis.

As a machine designer you will have to resolve many close decisions. You'll have to analyze the functions of the machine and know the capabilities —and the economics— of available drives. Here are the basic factors.

WHICH DRIVE: Electrical, Mechanical, or

Choosing an adjustable-speed machine drive is a subject of debate. There are no formulas to determine the right drive to use. In practice, it may be possible to obtain the same performance with two different types of machine drives with little cost difference. How, then, does a designer decide which drive to use?

The answer will most likely be found by first learning and understanding the machine problem, which includes a knowledge of the required accuracy, acceleration, velocity, horsepower, the load moment of inertia and compliance, temperature range, and load variations. A knowledge of the technical capabilities of each type drive, such as the response characteristics, speed range, horsepower capacity, torque-speed characteristics, space requirements, and maintenance problems will enable the designer to match the drive by its capabilities to the machine by its requirements. There will be many cases where one drive is as good as another, and a decision will be made on economic factors; and there may be many instances where the decision will be made on personal preference.

Four Areas of Application

Application of a machine will determine to some extent which drive should be used. Four possible areas of machine application are: A general-use machine; a process-type regulated drive; a numerically controlled contouring drive; a numerically controlled point-to-point machine drive. A general-use machine can include any manually operated machine used for metal cutting or forming, transferring, or other uses. In contrast, a process-type drive is usually considered to be a regulated drive where the output, such as speed or tension, is continuously regulated to a desired reference input. Some examples of these are found in steel rolling mills, paper mills, tension regulators, and the chemical process industries.

Tracer control, numerical contouring, or path-controlled machines are used primarily to machine workpieces with complicated shapes, such as dies. The point-to-point numerically controlled machine is used for machining parts where the cutting operations are in a straight line from one point to another. Such machining operations as boring, drilling, and straight-line milling are examples of point-to-point machining. It is possible to use path control for point-to-point machining, but it is difficult to get satisfactorily machined surfaces using point-to-point control for path control operations no matter how short the straight lines are.

It should be obvious that a general-type machine application could use any of the three types of drives. Process-type machine applications will require a regulated drive which can best be suited to an electric or hydraulic drive. The tracer-type control and numerical-path control will require independent drives for each axis and will usually be a feedback control system. The electric and hydraulic drives are best suited to this application. Point-to-point numerically controlled machines will also require a feedback control system since these drives are used largely for positioning. In this application, the electrical, mechanical, or hydraulic drive can be used.

Mechanical Drives

Of the three types of machine drives under discussion, the mechanical drive was the first used, dating back to the water wheel, belt, and pulley era. With the advent

[1] Senior Electrical Development Engineer.

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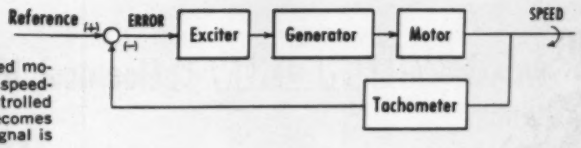


Fig. 1 Right, A separately exited motor-generator drive used in a speed-regulating system where the controlled output is speed. The system becomes a regulator when a feedback signal is added with a tachometer.

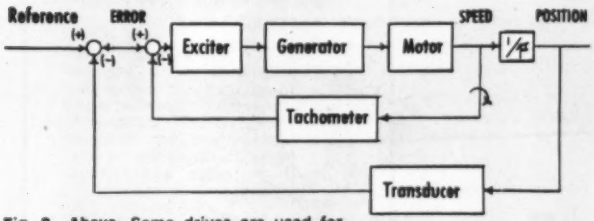


Fig. 2 Above, Some drives are used for positioning (a type 1 servomechanism), and may include a speed regulator as shown. The transducer integrates velocity and provides a feedback voltage proportional to position.

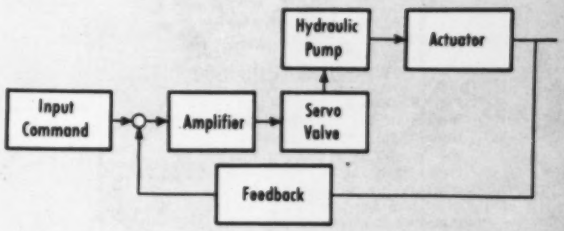
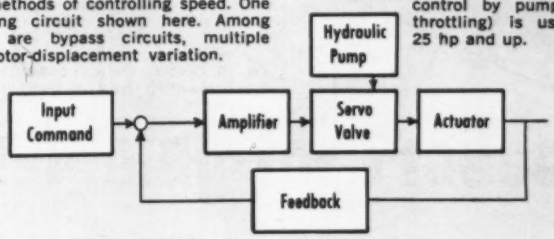


Fig. 4 Above, In hydraulic systems, speed regulation is often controlled by a variation in pump delivery. In general, speed control by pump variation (instead of throttling) is used in power sizes of 25 hp and up.

Fig. 3 Right, For hydraulic systems, there are a number of methods of controlling speed. One is the throttling circuit shown here. Among others, there are bypass circuits, multiple pumps, and motor-displacement variation.



Hydraulic?

of electrical drives, and later the hydraulic drives, the mechanical drive has not become outmoded. A large proportion of the machine drives in use are mechanical. The alternating-current motor may be the prime mover, but the speed changing is mechanical. Efficiency of mechanical drives is on the order of 90 per cent. Choice of a mechanical drive depends on the load factors of power, speed, and torque required.

It is possible to use a single mechanical drive for all axes, defined as a dependent drive, with the "time-sharing"[2] control technique, to get performance approaching that of two independent drives at the cost of a single drive. An important point to remember is that a path-controlled system also can be used for point-to-point operation. The future trend of numerical control may combine path control and point-to-point control which will require independent feedback-controlled drive systems. The application requirement of a regulated drive is therefore somewhat limited to the electric and hydraulic drives. The mechanical drive is widely used as a constant-horsepower stepped-speed application in machine-tool spindle drives.

[2] G. W. Younkin, "Dual-Purpose Synchronizing and Dependent-Drive Time-Sharing for Point-to-Point Numerical Control," AIEE Paper DP 60-647, January, 1960.

Hydraulic Versus Electric

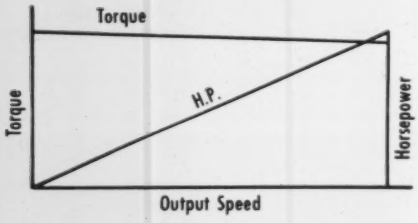
Hydraulic drives have some definite performance advantages over the electric drive, but the hydraulic drive also has disadvantages which overshadow some of its advantages. Torque-to-inertia ratios of hydraulic drives are much greater than with electric drives; hence the

Table 1 Comparison of Adjustable-Speed Electric Motors and Drives

	D-c Motors	A-c Motors		D-c Generator and D-c Motor Combination		
Speed range	8/1 by control of armature voltage through constant torque range up to base speed. 6/1 by control of field current in constant-hp range above base speed. 48/1 by armature and field control.	Single phase motors 4/1. Polyphase motors: Squirrel cage—up to 4/1 by reconnecting windings. Wound rotor—2/1 by varying rotor resistance.		60/1 by control of separately excited generator field resistance. 240/1 by electronic amplifer exciter for generator. 100/1 by magnetic amplifier exciter for generator.		
Horsepower	Series up to 200 hp; shunt up to 50 hp; compound any size.	Single phase—fractional to approximately 5 hp. Polyphase—not limited.		Not limited.		
Cost				Complete Drive Cost		
		Single Phase	Polyphase wound rotor	Rotating amplifier	Electronic amplifier	Static amplifier
1– 5 Hp	$ 400–$ 1000	$200–$ 500	$ 400–$1000	$ 1500–$ 2000	$ 2000–$ 3500	$ 1000–$ 3000
5– 10 Hp	$1000–$ 1500	$500–$1000	$1000–$2000	$ 2000–$ 3000	$ 3500–$ 5000	$ 3000–$ 4000
10– 20 Hp	$1500–$ 2500		$1500–$3000	$ 3000–$ 6000	$ 5000–$ 7500	$ 4000–$ 7000
20– 50 Hp	$2500–$ 4500		$2000–$4000	$ 6000–$13000	$ 7500–$12000	$ 7000–$12000
50–100 Hp	$4500–$ 6500		$3000–$6000	$13000–$19000	$12000–$19000	$12000–$20000
100–200 Hp	$6000–$10000		$6000–$9000	$19000–$35000		$20000–$38000

WHICH DRIVE: Electrical, Mechanical, or Hydraulic?

Fig. 5 **Below,** Pump and motor circuits can be of the fixed-displacement type or the variable-displacement type. Here is the variable-delivery pump and fixed-displacement motor, for machine-tool feed drives.



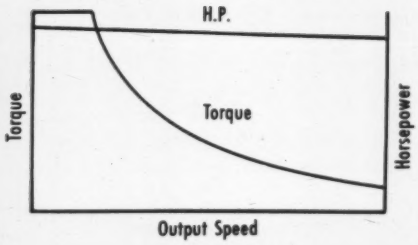
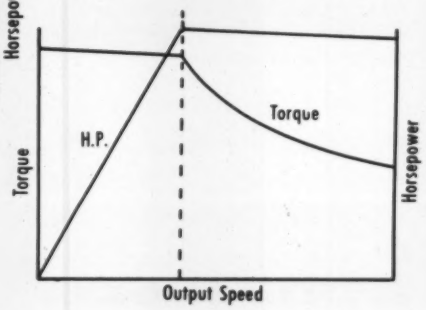


Fig. 6 **Above,** Output characteristics resulting from a fixed-displacement pump and a variable displacement motor, providing constant horsepower and variable torque for spindle speed drives on machine tools

Fig. 7 **Below,** Output characteristics of a variable-displacement pump and variable-displacement motor combination. Outstanding capability of the hydraulic drive is its ability to give high torque and fast response.



response of hydraulic systems is much faster. Output torque of an electric drive is linearly related to the control input, while the slightest opening of the hydraulic valve has immediate results in almost maximum torque. The output of an electric motor is limited by the saturation flux density of the iron which limits the torque that could be developed, where hydraulic systems can deliver much higher torques at higher pressures.

With machines having two or more axes, the number of separate motors and generators required can be an economic limitation, where only one hydraulic pump is required with a throttling-valve control system. Hydraulic systems can have problems of oil compressibility, and heat can change oil viscosity, changing performance characteristics.

High-pressure hydraulic systems require less space for equivalent-horsepower-rating electric motors, but the piping problem with hydraulics can result in leakage and lower efficiency if many bends are encountered in the piping; and with the possible lower efficiency, a higher hydraulic horsepower rating may be required. The hydraulic motor may be smaller in size and have a higher torque-to-inertia ratio, but it is easier to pull wires for an electric motor than to run piping with all the possible leakage and lower-efficiency problems. The higher hydraulic pressures used to keep space requirements down will also reduce the overload rating of the hydraulic system.

Hydraulics have advantages for clamps and indexing tables since applied force can be varied by adjusting a relief valve. Fluid contamination can be a problem with hydraulic systems if proper preventive maintenance of oil filters is not carried out. In general, hydraulic drives are suited to machine applications requiring fast acceleration or deceleration and rapid reversals usual in a linear motion.

Table 2 Advantages Over Disadvantages of Hydraulic Control by Servo Valve Throttling the Motor, and Servo-Valve Control by Pump-Flow Variation

	Advantages	Disadvantages
Control by pump flow variation	1 Constant gain. 2 High efficiency. 3 Capable of very high horsepower output.	1 Usually takes more space than a throttling motor flow arrangement. 2 Frequency response usually not as great as a throttling motor flow arrangement. 3 One pump is required for each hydraulic drive.
Control by throttling motor flow	1 Lower cost. 2 High-frequency response. 3 Compact over-all drive package. 4 A single constant pressure oil pump can supply several drives on the same machine.	1 Gain varies with load. 2 Maximum theoretical efficiency 66%. 3 Usually limited to below 25 hp.

Relative Costs

For horsepower ratings up to 5 hp, the electric drive will probably cost less than the hydraulic drive, and from 5 hp to 25 hp the relative costs will be about the same. Above 25 hp, the hydraulic drive will have a lower initial cost. In any relative cost comparison, the prime mover must be included, as with the oil pump in the hydraulic drive and the electric drive motor in the mechanical drive.

Acknowledgments

The author wishes to acknowledge with appreciation the co-operation of the following organizations in the preparation of this paper:

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Vickers, Inc., Machinery Hydraulic Division, Detroit, Mich.

DESIGN ENGINEERING '61

By C. E. Warner[1] and R. L. Berg,[2]
General Electric Company, Schenectady, N. Y.

Today, you've got to be right the first time. Here are the methods by which General Electric searches out new manufacturing processes at the beginning, before the design of the machine is set, developing production know-how in the design stage.

PRODUCIBILITY— Designing for Production

THE GOAL of a producibility effort is to introduce manufacturing-process knowledge early in the product-design cycle so that the product can be produced at the optimum manufacturing cost.

We have always had a cost objective. What is new is the fact that competition is keener than it has ever been—both domestic and foreign—and the pace of major product change is faster than in the past decades. With this increased competition and change, it has become necessary for us to put the product in the market place at an "optimum" cost at its introduction. We just do not have the time to conduct the usual cost-reduction activities during the product's life. Business will continue to go to those that develop the techniques which allow them to provide products that are "right the first time" from a cost standpoint. To state this another way, we should say that the products will have to be producible at their introduction.

In Fig. 1, neat packages of responsibility are indicated. However, the fallacy in this approach is that it provides practically no opportunity for overlap between functions. Since all the aspects of product design and development are interrelated, isolated decisions by any single function will have a tremendous influence on the work of succeeding functions. In fact, early decisions actually limit, and indeed predetermine, the contributions which later functions can make. So while we may have achieved a so-called integrated product design, there remains the question, "Have we achieved integrated product cost?" The answer would be, "Probably not." Having recognized this, the next question might be, "How can we make our product more producible?"

Inadequate Measures

A common interpretation of how a product can be made more producible consists of a detailed review of the product drawing before release to the factory. However, aside from merely adding another step to the traditional development cycle, there are at least three weaknesses in this arrangement: Since product design has been carried to the point where the significant cost has been established, only minor changes can be effected; there is not sufficient time left to make any major changes; and once any part of product design has been settled upon, there is an obvious natural resistance to additional changes.

Such programs are traditionally hit or miss, and lacking in continuity. The decisions made are of necessity short range, and emphasize the individual product's cost at the possible expense of the over-all business objectives.

The decisions made by Marketing and Engineering during the product-development cycle will finally be translated into actual manufacturing costs. Manufacturing can and does affect the manufacturing costs by doing the best job we can with the processes that are dictated by the design. However, the major part of the manufacturing cost has been predetermined early in the development cycle. Therefore the design of the product and the selection of manufacturing processes must be integrated on a parallel basis.

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[1] Manager—Advanced Manufacturing Engineering Service.
[2] Consultant—Producibility Engineering.

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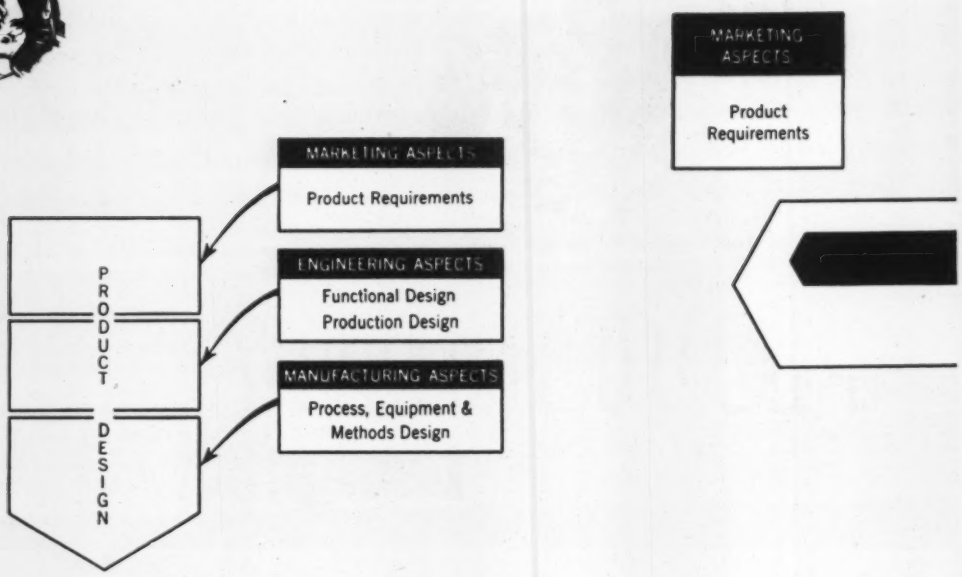


Fig. 1 The traditional product-design cycle which supposedly integrates product design. But does it integrate product cost? Can you make the product more producible?

A Producibility Program

Fig. 2 illustrates how the work of the producibility program can be segregated into two phases: Process selection and process-detail selection.

The process-selection phase starts at the beginning of the product-development cycle and extends to the detail-design stage. It is at this point that the basic process is selected—for example, should a part be forged, fabricated, cast, or drawn?

The process-detail selection phase starts in the detailed-design stage of the product-development cycle and extends to the actual manufacture of the product. In this phase, consideration is given to getting the most out of the process selected—for example, minimizing the draft and gating problems in casting as well as tooling reference points, stock allowances for machining, and required tolerances and finishes.

In the area of process selection we can effect potential cost savings of dollars, while in the work area of process-detail selection we save pennies. We do not suggest that nothing be done in the "penny" area, but rather, that this is an indication of the level of effort which should be placed in each area.

There are three basic steps in a producibility program that Manufacturing must first consider and then follow up with action:

1 The searching out of manufacturing information.
2 The review, organization, and documentation of this information.
3 Assistance to engineering in the application of this information to the product design they are developing.

The Search

First, the searching out of manufacturing information. Engineering is vitally concerned with several kinds of manufacturing information inputs at each stage of product design. These inputs are:

a Data on shop capabilities—i.e., what can we do with "in-plant" equipment?
b New manufacturing processes—i.e., what can we do with equipment we can obtain?
c Spontaneous ideas that lead to improved processes, as well as product designs.

So the first searching operation should be to uncover and document data on our shop's capabilities. You may say, "Surely you have people who know the shop inside and out." True, they do know it, but only in relation to specific parts. A fresh and thorough documentation of shop capabilities is essential. Then there remains the problem of determining what direction we are going in regard to new manufacturing technology. Manufacturing technology is dynamic.

Every process has a characteristic volume level at which it is best applied. Information on these volume levels should be available to the engineering organization so that they are not inadvertently designing parts to suit a process that is best used at 10,000 parts when the anticipated volume is actually only 1000.

This kind of documentation will often reveal existing weaknesses in in-plant processes and point out the need for up-dating particular processes. "You cannot design tomorrow's products with yesterday's processes."

Finding New Processes

It is important to recognize that there are two kinds of search: Directed search and random search.

1 In directed search, activities are aimed toward finding the solution to a specific problem. We usually focus on other industries which produce products or parts similar to ours.

Fig. 2 The two phases of producibility work. Process selection starts at the beginning: Should a part be forged, cast, drawn? Then comes detail — improving the part for the process.

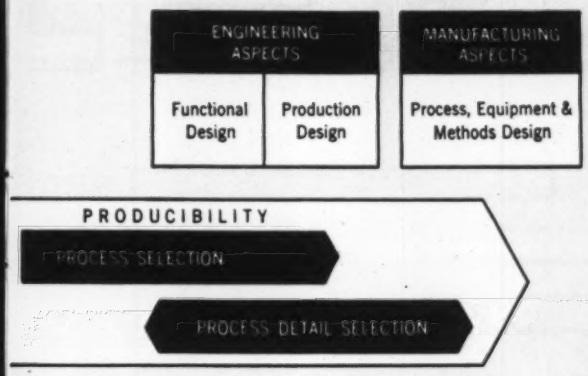
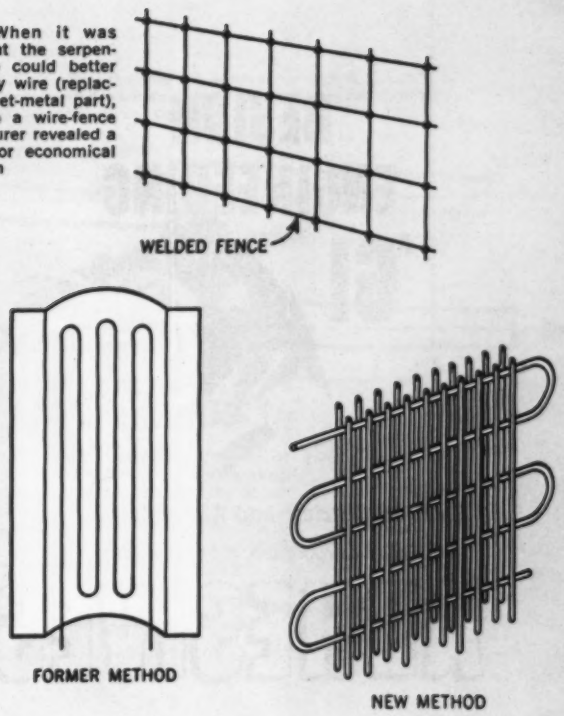


Fig. 3 When it was found that the serpentine tube could better be held by wire (replacing a sheet-metal part), a visit to a wire-fence manufacturer revealed a process for economical production



2 Random search is a search of businesses and manufacturing-technology areas completely unfamiliar to us. Random search can produce major changes in the processing of parts.

Here are two examples of what we mean by "search" and what types of information can be found:

Consider the turbine blade shown in the sketch at the beginning of this article, a part important to many products built by our company. A random search was made for other items that might bear some resemblance to the blade, and to determine if they were made by any unusual process. This random search turned up a common household item—a table knife—and the subsequent development and utilization of a rolling process to form our part.

Another part had been traditionally made by spot welding a serpentine tube to a formed sheet-metal part. The same effective surface area could be obtained by replacing the sheet-metal part with a large number of welded wires and would result in substantial weight savings. A search was instituted to find products that had similar problems. This brought about a visit to a welded-fence manufacturer and the subsequent adoption of this fence processing system to our part. (Fig. 3.)

A Review Team

The output of the "search" activity is our next concern. This is where we must consider Point 2 of the over-all producibility program: Review, organization, and documentation. We recommend the setting up of a marketing-engineering-manufacturing review team to evaluate the new process information, data, and ideas coming out of the search activity, or from anywhere in the organization. This team is made up of people who can take immediate action on proposals showing good potential.

When the volume of new information warrants, the review team is called together. The ideas are presented, explored, and earmarked for potential applications.

The review team serves three important purposes:

1 It makes key people aware of "new" information so that specific action can be taken.
2 It monitors the search activity to assure those responsible that worth-while output is being generated.
3 It forms a recognized, receptive input point for all new manufacturing innovations, no matter what the source.

The ideas and new data reviewed by the review team must be properly organized and documented. This results in the addition of data to the previously mentioned reference source on the in-plant capability.

The producibility specialists develop into a manufacturing-technology resource for engineering and marketing. Through direct assistance, they bring process know-how to bear on the proposed product designs.

Getting Together

The exchange of design proposals and counterproposals then begins between marketing, engineering, and manufacturing. As design alternatives emerge from the marketing-engineering-manufacturing producibility effort, a complete analysis—highlighting cost—is required. Here the abilities of a great many specialists in manufacturing are directed to this job by the producibility people. This sequence of proposal, counterproposal, and analysis continues until the producibility criteria are met.

It is not a question of whether we can afford to support such an activity—it is a question of whether we can afford not to have it.

DESIGN ENGINEERING '61

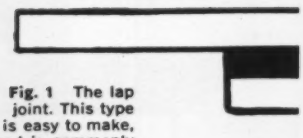


Fig. 1 The lap joint. This type is easy to make, and is commonly used since adhesive bonds exhibit high strength in shear.

By H. R. Butzlaff and K. F. Charter,
A. O. Smith Corporation, Milwaukee, Wis.

ADHESIVES for the Bonding of

Sooner or later you'll design parts for adhesive bonding. Here are the factors that enter

INTEREST in the possibilities of synthetic resin and rubber adhesives for the bonding of metals was awakened in this country by the development of "Cycleweld" in 1942. During the war, aircraft subassemblies such as wing flaps, stabilizers, heating ducts, bomber floors, etc., were manufactured. A few years earlier, the "Redux" process developed by Aero Research Ltd. in England was announced. The DeHaviland Aircraft Company, Ltd., first used Redux in their Hornet and Mosquito aircraft during World War II.

Progress in metal-to-metal adhesive bonding has progressed rapidly in the aircraft industry since the last war. The B-58 "Hustler," for example, uses a great amount of bonded construction. In automobiles, adhesives are used extensively in brake linings. The use of adhesives can well be expected to expand into other metal bonding applications in the future.

Why Use a Bonded Joint?

1 In adhesive bonds the load is more equally distributed than in other type joints. Smoother contours are produced; gaps and voids are minimized. This minimizes stress concentrations, which in turn may produce better fatigue properties and may allow a reduction in metal thickness.

2 Adhesives are elastic enough to absorb stresses created by flexing and differences in coefficients of expansion.

3 Adhesives can join dissimilar metals and materials, and in some cases are the only method of joining.

4 Bonded joints dampen vibrations.

5 Cost savings can sometimes be effected by eliminating fastener costs, reducing metal forming and machining operations.

6 Large areas can be bonded in a relatively short time.

7 A general reduction in weight can be accomplished; i.e., reduced metal thickness and elimination of fasteners.

8 The adhesive bond can provide electrical insulation and thus minimize galvanic corrosion.

9 Does not embrittle aluminum or magnesium or tend to warp steel as welding may do.

10 Eliminates the need for high temperatures as used in welding.

11 Leaves good surfaces for organic coatings.

12 Adhesives provide a sealing action in addition to bonding.

13 Give easier alignment of joined parts where alignment is critical.

Reasons Why Not

1 Heat and pressure may be needed to cure the adhesive and this may make it less feasible than another method of joining.

2 Jigs and fixtures for applying the heat and pressure may be expensive.

3 Application of some adhesives is susceptible to high humidity and/or low temperatures.

4 There is not too much background in durability and permanence tests.

5 It is a basic fact that organic compounds are not as stable as metals at elevated temperatures.

6 Strong and reliable bonds can only be effected if the surfaces to be bonded are clean.

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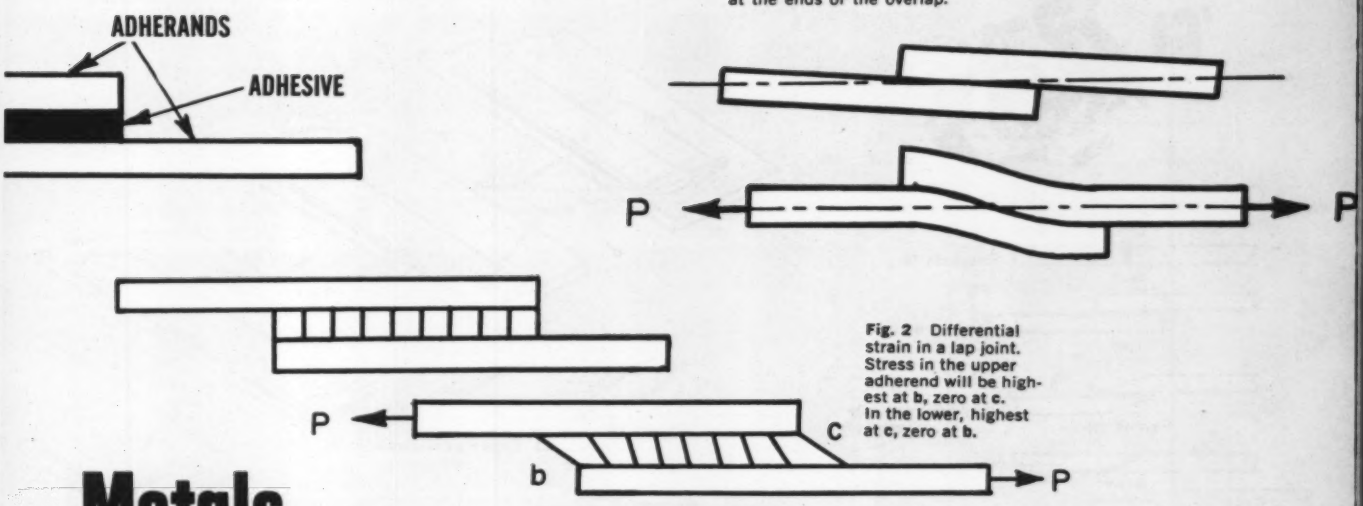


Fig. 3 The bending of adherends due to eccentric loading. The tearing or peeling stresses are concentrated at the ends of the overlap.

Fig. 2 Differential strain in a lap joint. Stress in the upper adherend will be highest at b, zero at c. In the lower, highest at c, zero at b.

Metals

into the decision to use adhesives, the strengths and limitations of these bonding materials.

7 Stronger and more reliable bonds can be effected if the parts to be bonded are closely mated.

8 The time required to form a bond may add unreasonable cost to a product.

9 Inspection and nondestructive testing are difficult.

10 Other methods of joining may be stronger.

Adhesive Joint Design

Parts to be bonded with adhesives must be designed properly to obtain the maximum strength properties. Factors dictating the joint design are dependent upon the direction and magnitude of the load and whether the stress will be applied continuously, short term, or intermittently.

Stress Distribution in Lap Joints. Most adhesives used for structural metal-to-metal bonding are relatively rigid but have some elastomeric properties. They are strongest in direct shear or tension and weakest in peel and cleavage. A large portion of the engineering data on metal-to-metal bonds have been obtained as shear strengths with plain lap joints (Fig. 1). This type of joint is easy to make and is quite common in manufactured items using adhesives since adhesive bonds exhibit high strengths when stressed in shear. Stress concentrations are produced in the bonded joint just as they would be in an unfilleted weld or braze.

Two causes are mainly responsible for these stress concentrations: Differential strain of the joined members, and bending of the joined members.

Referring to Fig. 2,[1] each member bears the full load P just before the joint and transmits it gradually to the other through the adhesive. Thus the stress of the upper adherend will be highest at b and will gradually diminish until at c it is zero. However, in the lower member the stress will be greatest at c and diminish to zero at b. When the members obey the laws of elasticity, these members will develop strains proportional to the stresses. This results in higher stresses in the adhesive at each end of the overlap.

The members of the lap joint are necessarily offset by the amount of their thickness. This eccentric loading gives rise to a bending moment which will tend to pull the members apart. Under this moment the members will yield if the applied load is great enough. This is shown in Fig. 3. The tearing or peeling stresses are concentrated at the ends of the overlap, and, combined with the effects of differential straining, they considerably reduce the strength of lap joints.

The high proportion of the failure load carried in the edges of lap joints is illustrated by the fact that an adhesive showing an apparent bond strength of 3000 psi with a one-inch overlap will fail at about 2500 lb when the edges of the lap are bonded with a $^1/_4$-in-wide band of adhesive on each edge. The center half of the lap thus contributes only about $^1/_6$ of the total strength. This indicates also that the apparent bond strength is not proportional to the length of overlap.

The strength of a lap joint also depends on the thickness of metal and the yield strength of the metal. The thickness of the metal and the overlap length have been combined into the term "joint factor" and related to failing stress.

The Glenn L. Martin Co., working with aluminum alloys, has determined that the optimum overlap length is approximately twenty-five times the metal thickness for the particular adhesive they were using, a phenol

[1] A bibliography covering all references to the work of others appears in the original paper.

ADHESIVES for the Bonding of Metals

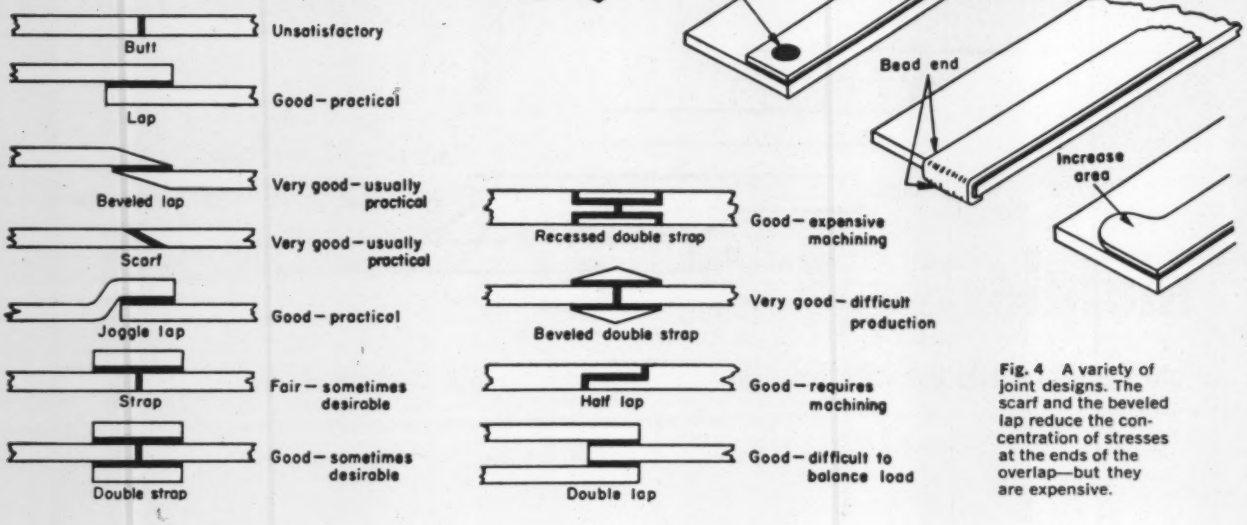


Fig. 4 A variety of joint designs. The scarf and the beveled lap reduce the concentration of stresses at the ends of the overlap—but they are expensive.

formaldehyde-vinyl butyral tape. The strength of a lap shear joint is directly proportional to the width of the joint. The width and overlap factors have been verified in our laboratory.

Other Type Joints. A variety of joint designs have been proposed and are illustrated in Fig. 4. The scarf and the beveled lap are the most efficient because they reduce the concentration of stresses at the ends of the overlap. In production, the beveled and scarf joints would be expensive and are therefore not generally recommended.

Effect of Peel and Cleavage Stresses. Peel stresses must be kept to a minimum for properly designed adhesive bonded joints. Fig. 5 illustrates some of the steps.

As mentioned previously, it is most desirable to bond the parts so that the adhesive is stressed in shear. In heavy sections, a bond that is placed in pure tension should be satisfactory. However, cleavage stresses usually result which reduce the strength of the joint. Fig. 6 illustrates methods of minimizing cleavage.

The Effect of Temperature on Shear Strength. The thermosetting phenolic-synthetic rubber adhesives tend to show stronger bonds at high temperatures than do other adhesives. The work toward better high-temperature adhesives is receiving attention largely because of the demands of the aircraft and missile industry. More recently epoxy phenolics, high functionality epoxies, and silanes have been considered. Forest Products Laboratory has been studying the effects of temperatures from -100 F to $+1000$ F on the strength properties of seven commercial metal bonding adhesives. Lap shear, long-time load, peel, and fatigue tests are involved. Tensile shear strengths of 2300 psi at 350 F and over 1100 psi at 500 F have been reported.

Strength Properties

The improvement of bonded structures over riveted structures in fatigue in aircraft is a major advantage of bonded joints. On a fatigue test of a helicopter-blade skin with adhesive-bonded stringers and local rivet reinforcings for attaching the skin to the rib structure, failure took place by a crack developing at a riveted joint after 150 million cycles of reversed stress. The adhesive bond had not failed. C. J. Moss has described other fatigue tests made by the Bristol Aeroplane Co., Ltd., in which Redux-bonded panels were in perfect condition after six times as many reversals as caused cracking in riveted panels.

Another example is in a test panel for the B-36's made by Consolidated Vultee. The number of cycles to failure for three methods of attachment are as follows: Spot welding, 12×10^6 cycles; riveting, 18×10^6 cycles; adhesive bonding, 27×10^7 cycles. The failures of the spot-welded and riveted sections were due to stress concentrations developing at the weld or rivet holes.

It has been mentioned that structural adhesive joints should be designed to minimize the effect of peel and cleavage. Peel tests are usually conducted with one flexible member bonded to a rigid member and are tested by peeling the flexible member at an angle of 90 deg or 180 deg. Recently, ASTM has prepared a new test method for peel, based on a climbing drum. For structural adhesives the peel strengths are in the range of

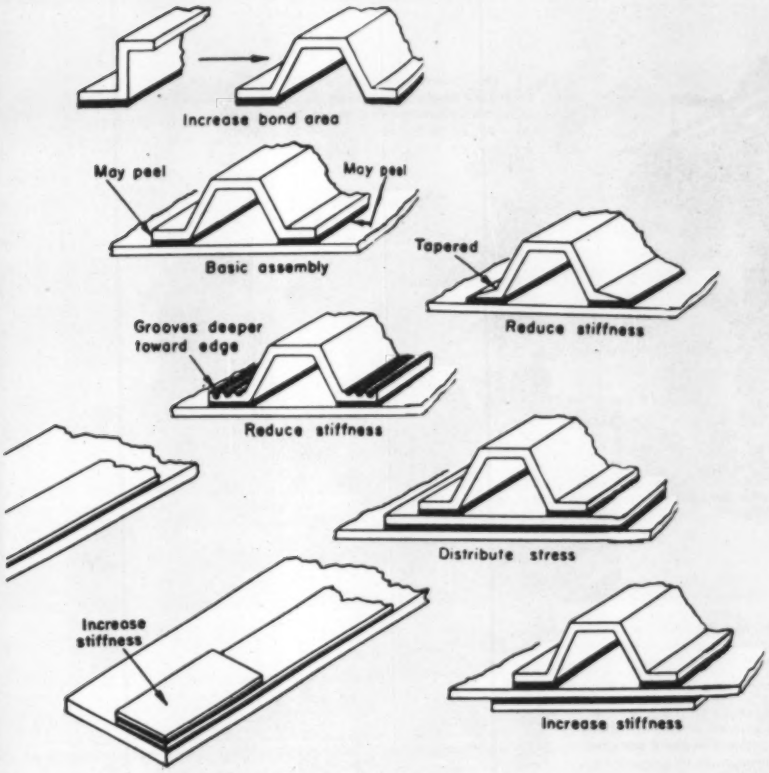


Fig. 5 Illustrating some of the steps that can be taken to minimize peel stresses

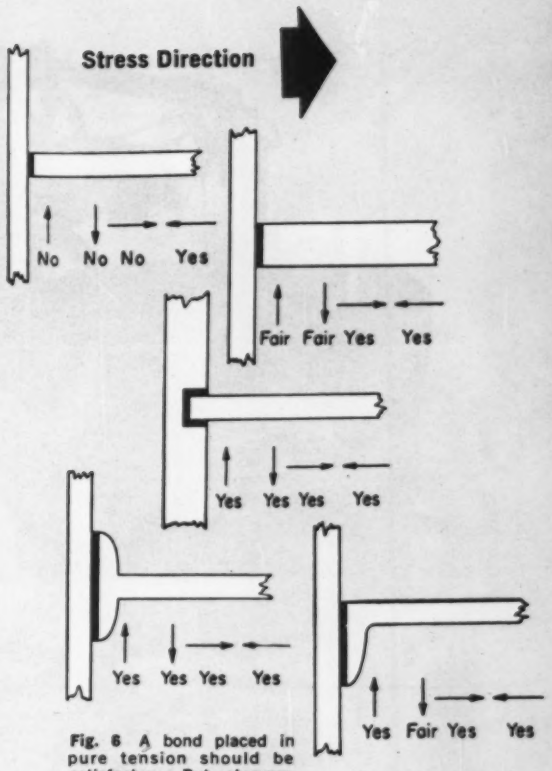


Fig. 6 A bond placed in pure tension should be satisfactory. But cleavage stresses usually result. Here are methods of minimizing cleavage.

10–25 lb per in. of bond width. The high-modulus, rigid adhesives, such as unmodified epoxies and phenolics, have lower peel strengths than do lower modulus adhesives such as rubber-modified phenolics. Peel strengths increase as the bond thickness increases. One opinion is that the peel test is preferred to lap-shear tests as a production control test because it is much more sensitive to changes in adhesive, surface preparation, etc.

Adhesive bond strengths when tested in pure tension are usually considerably stronger than when tested in tensile-shear. The introduction of cleavage, however, can greatly influence the apparent tensile strengths. An adhesive that will demonstrate a tensile strength of 6000 psi with one type of tensile specimen will fail at about 2700 psi with another type of tensile specimen in which cleavage is apparently introduced.

Wittman has conducted tests relating tensile-shear strength at room temperature to the rate of loading of the specimens. His results indicate that for the more rigid adhesives, phenolic-vinyl butyral and epoxy, the tensile-shear strength remains fairly constant as the rates of loading increases. The shear strength of the less rigid adhesives, phenolic-synthetic rubber, increase markedly as the loading rate increases. A round-robin test program conducted by ASTM Committee D-14 on Adhesives found that steel and aluminum tensile-shear specimens showed very little change in strength when tested at rates of stress from 600 to 2000 psi per minute. It was also shown that it is not possible to express one rate of stress as being equivalent to a rate of strain for adhesives of different elastic modulus.

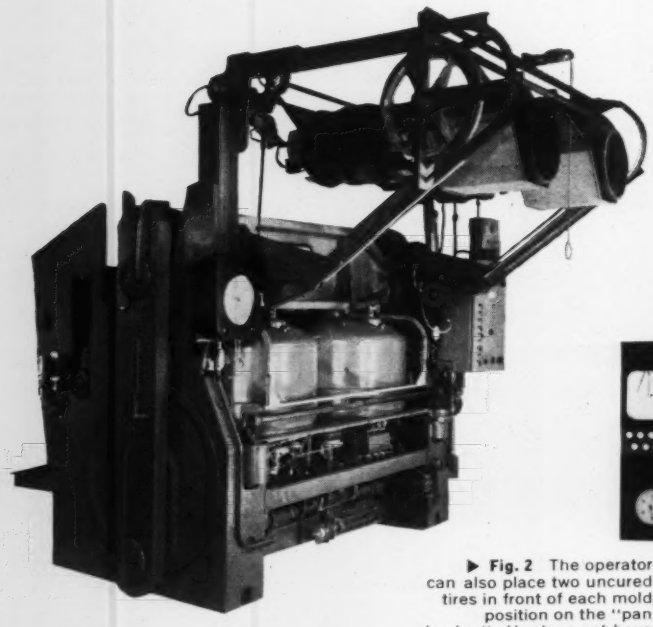
Durability and Permanence

The bond strength determined shortly after a bond has been formed is not an indication as to what the strength will be after aging or exposure to various environments.

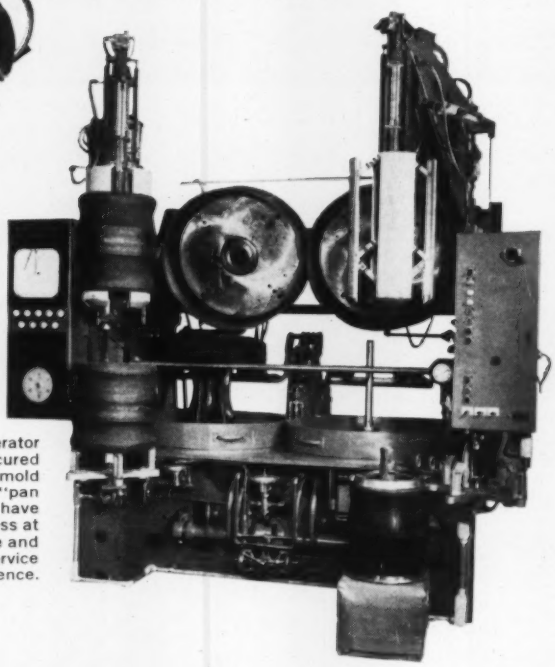
There is not much information available on the permanence of metal-to-metal bonds, but there is an abundance of data on the wood-to-wood bonds. Most of the metal-to-metal data pertain to aluminum. Data on steel-to-steel bonds are very meager.

Metal-to-Metal Bonds. Forest Products Laboratory started outdoor weathering tests in 1953 in six locations from Alaska to Panama. Some adhesives have shown good performance after three years' exposure in Florida and the Canal Zone, while other adhesives deteriorate. Exposure in Madison, Wis., New Mexico, and Fairbanks, Alaska, was generally less severe than the Florida and Canal Zone exposures. Forest Products Laboratory is continuing this work. Painted steel-to-steel bonded specimens have been exposed on our factory roof in Milwaukee for over a period of five years with very little change in strength. In some cases an increase in strength was found.

Military Specification Mil-A-5090B requires adhesive bonds to withstand salt-spray exposure and immersion in water, ethylene glycol, anti-icing fluids, oils, and various fuels. In general, many adhesives meet these requirements. Unpublished work in our laboratory has shown that 72 hours in boiling water provides a good accelerated test for comparing adhesives for water resistance.



◀ **Fig. 1** The "vertical chuck loader" with which the 40-in. twin Bag-O-Matic press is equipped is capable of keeping two tires in reserve for each mold position. An operator is required for placing uncured tires on the chuck table.



▶ **Fig. 2** The operator can also place two uncured tires in front of each mold position on the "pan loader." He does not have to return to the press at the end of each cure and can therefore service the units in sequence.

The automatic and semiautomatic handling of tires in the Bag-O-Matic

LOADING A TIRE-

AUTOMATIC and semiautomatic handling of passenger tires to and away from Bag-O-Matic tire-curing presses is a relatively new development. The possibility of automation was realized when the original diaphragm or Bag-O-Matic type of curing equipment was installed in the tire industry. Not until it was proved that automation in itself was not only laborsaving, but that from 15 to 25 per cent more production could be obtained from the curing presses, were sizable installations made to give it a trial. Since the first installation three years ago, consisting of 80 twin Bag-O-Matic units in one plant, many others have been made. There are now 32 separate installations of semiautomatic or completely automatic operations in North America.

In manual operation, all presses in a line had to open in sequence so that the operator could advance from one press to the next. In the semiautomatic or fully automatic press, since the uncured tires are always waiting to be loaded into the press when a cure has been completed, it is possible for each press to be set for the allowable minimum cure for the particular tires being cured. This becomes even more important with the shorter cures that are becoming increasingly popular.

Principal Advantages of Automatic Handling

Among the main advantages of the automatic loading and unloading curing presses are:

1 No allowance has to be made for the possibility of molds cooling between cures. With manual operation, the presses are often left in the open position waiting for an operator, causing a temperature drop. With automation, the press is open the same time between each cure, therefore no variable or appreciable temperature drop is realized.

2 The automatic press eliminates many of the variables which are present on a manually loaded press. The automatic shaping becomes much more consistent because the temperature of the diaphragm and piping remains constant.

3 Apparently longer diaphragm life can be expected on an automatic press because it is held in the collapsed position for a minimum amount of time.

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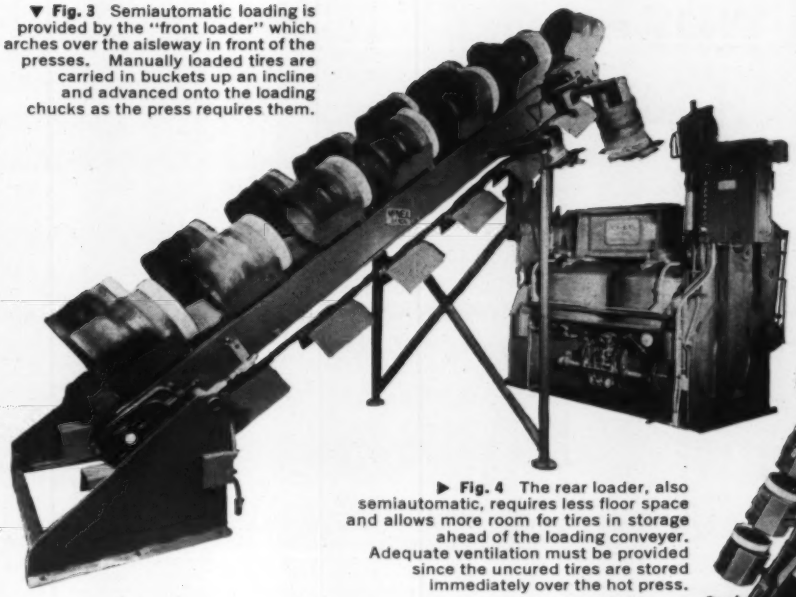
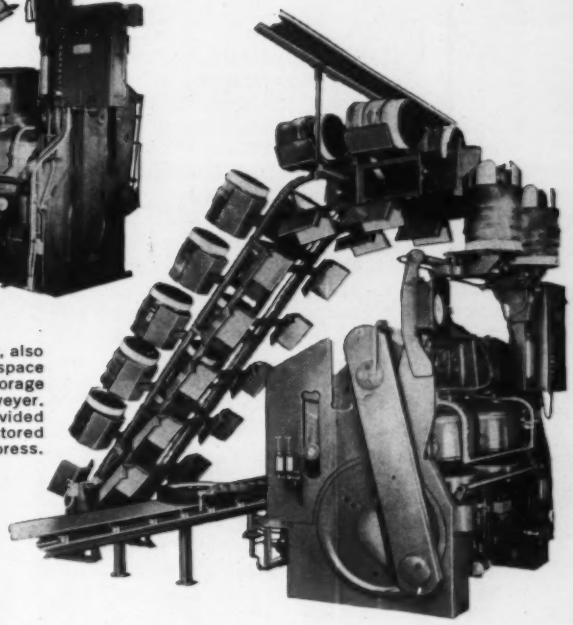
[1] Vice-President and Director of Engineering.

Contributed by the Rubber and Plastics Division and presented at the Rubber and Plastics Conference, Erie, Pa., October 9–12, 1960, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Condensed from Paper No. 60—RP-7 originally entitled "Automated Tire Curing Room."

▼ **Fig. 3** Semiautomatic loading is provided by the "front loader" which arches over the aisleway in front of the presses. Manually loaded tires are carried in buckets up an incline and advanced onto the loading chucks as the press requires them.



▶ **Fig. 4** The rear loader, also semiautomatic, requires less floor space and allows more room for tires in storage ahead of the loading conveyer. Adequate ventilation must be provided since the uncured tires are stored immediately over the hot press.



By L. E. Soderquist,[1] Mem. ASME
The McNeil Machine & Engineering Company, Akron, Ohio

curing process—plus automatic inflation as the tire leaves the press

CURING MACHINE

4 Since all presses are operated independently it is not necessary to redistribute molds in a press room so that the longer cures can be in one row and the shorter cures in another row.

Because individual operation is possible in automatic presses, one company operates 64 automatic 40-in. passenger-car-tire presses on an average $14^1/_4$-min cure which delivers 192 tires per day for each twin press. It has been found from experience that presses can be operated semiautomatically, taking advantage of the independent operation of the press as long as there are two uncured tires ahead of each mold position.

Steps Toward Automation

The first step toward automation in the curing room was the ejection of the tire to the rear of the press onto a belt conveyer immediately after the diaphragm had been extracted. Even in cases where automatic loading has not been applied to presses, automatic unloading has almost become an accepted standard. Where 45 per cent of all Bag-O-Matic in North American was delivered with automatic unloading in 1956, over 95 per cent of these presses were furnished with automatic unloading in 1960.

The basic means of placing uncured tires into a press is with the use of a chuck equipped with expanding and retractable paddles which grab the tire and place it into the press. Various methods can be used to place the uncured tires onto these chucks. Presently automatic loading is being furnished on about 80 per cent of the presses being built.

No one standard technique of handling has been accepted throughout the industry. Various factors have brought about three distinct types of installations. The equipment carrying the tires to the press and away from the press has been designed around these three types, while the function of the press itself remains pretty much standard.

Type 1 Loader. Two different types of loading conveyers are capable of keeping in reserve two tires per mold position. One of these is known as the "vertical chuck loader," Fig. 1, and the other as the "pan loader," Fig. 2.

An operator is required for the placing of uncured tires either on the chuck table or in the pan in front of the press. Since he can place two uncured tires in front of each mold position, he does not have to return to the press at the end of each cure and therefore can service the units in sequence, placing one or two tires as required.

LOADING A TIRE-CURING MACHINE

This type of installation is the simplest of the three to be discussed and, as far as increasing production is concerned, will give the same increase as the fully automatic equipment. These loaders are normally recommended where the ticket is small on many sizes or what is known in the tire industry as "cat-and-dog" production. Naturally, in an installation of this type, a suitable conveyer system must be installed which will carry the various size tires to the region of the presses so the operator will have a stockpile of uncured tires on racks, trucks, or other suitable means, ahead of each press. Without this stockpile, he cannot keep the presses supplied for their maximum production.

Type 2 Loader. The second type of loader, which has become quite popular, still requires an operator, but instead of servicing each mold position in the press with two tires, he services a loader with six to 10 tires depending upon the size of conveyer. This loader has been named the "inclined loader" and is designed to carry tires in buckets up an incline onto the press-loading chucks. This conveyer acts as a storage or festoon for six to 10 uncured tires and it automatically advances the uncured tires to the loading chucks as the press requires them. This method of loading requires more capital investment than the first type. It also requires more floor space; however, it can handle a cat-and-dog installation and requires less attention by the operator. The operator can schedule his return to the press according to the number of uncured tires in front of each mold position.

There are several variations of these loaders for either from-the-front or over-the-rear loading of the press. The front loader arches over the aisleway in front of the presses and is shown in Fig. 3. To conserve floor space, there are similar conveyers where the inclined loader is at the rear of the press and carries the uncured tire over the take-away belt and press, onto the loading chuck as shown in Fig. 4. The rear loader, requiring less floor space, allows more room for tires in storage ahead of the loading conveyer. A problem of ventilation is created by this system. Because the uncured tires are stored immediately over the hot press, adequate ventilation must be provided since excess heat will cause the uncured tires to wilt into a distorted shape.

Type 3 Loader. The presence of the operator in the curing room is completely eliminated by the third type of installation which is referred to as being fully automatic. As of the date of writing, there are three such installations which are operating satisfactorily. This method is recommended when tires of various sizes are to be cured for a reasonably long period of time. This system, shown in Figs. 5 and 6, is termed the "shuttle pan loader." Each mold position on the press is equipped with a loading chuck in a horizontal position which is an integral part of the press itself. In front of each chuck is a shuttle pan which serves as a receiver for the uncured tires which are automatically dropped from a continuous overhead service conveyer. It shuttles the uncured tire onto the loading chucks when the chucks have set up a demand for the tire.

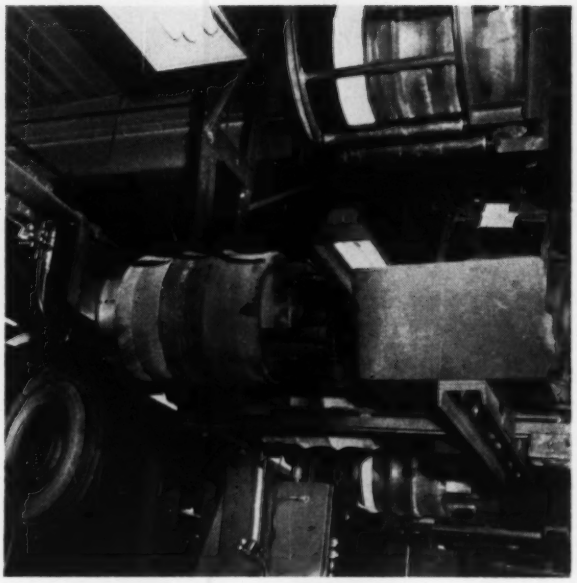


Fig. 5

In this particular installation, the service conveyer can best be described as a series of clamshells which are supported by a continuously moving chain conveyer. Each clamshell is equipped with an adjustable flag or indexing system so that it will handle only the tire size for which it is adjusted. This conveyer carries the uncured tire with its axis horizontal and surrounds the tire in such a way that it is capable of opening and dropping it directly downward. When the clamshell is empty it can be made to open at the proper time to receive a tire at the loading station.

The tires come from the building machines to an automatic sorting station with each size on a separate conveyer. The continuously running service conveyer passes over each loading station. At the proper station, the clamshell is automatically opened and the uncured tire is mechanically raised so that the clamshell can close around it.

After the conveyer travels to the curing room it passes down each row of presses in the room. At each mold position there is a selector switch arranged so that only the correct size tire can automatically drop at the proper press. As an uncured tire reaches the proper press the electrical selector switch will be operated and if the shuttle pan in front of the press is empty, the uncured tire will be deposited into this shuttle pan where it will remain until the loading chucks on the press require another uncured tire. As long as there is one in the shuttle pan, no other uncured tire will drop into that position.

As these are mostly twin presses, the electrical system is so interlocked that an uncured tire must be in both pans before operations can proceed. At the press, again, there are two tires in reserve—normally one on the loading chuck and one in the shuttle pan. This places enough reserve at each mold position to handle any delay in the next uncured tire arriving at the press. In the event that a particular uncured tire does not find a station at which to drop, it merely returns to the loading section and continues back to the pressroom to make its second round at which time it normally finds a position to drop.

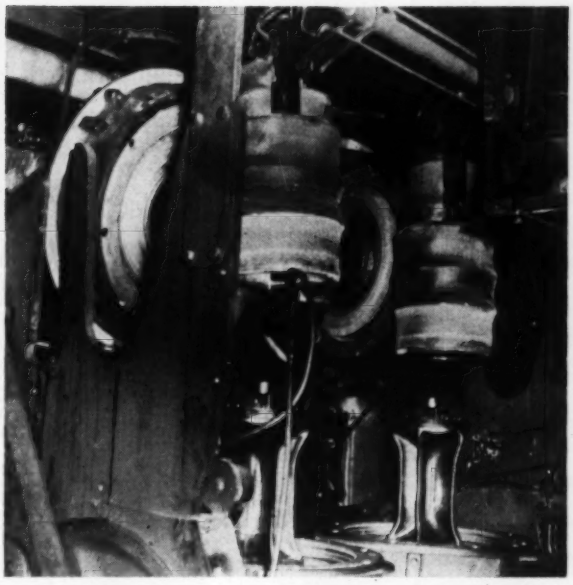


Fig. 6

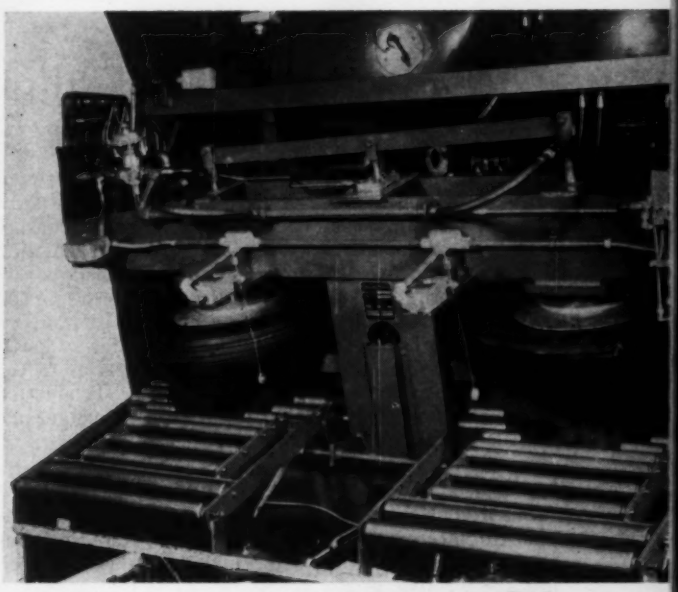


Fig. 7

After the tire is cured in the press it is discharged to the rear and is carried by belt conveyer to final inspection. This system is considered the most efficient type of automatic loading in operation today. There is a possibility of developing an automatic card type of system where the tires will be handled with complete automation from the buildin machine to the warehouse.

Truck Tires

Only the automatic handling of passenger tires has been discussed. There are installations of 55-in. truck-tire Bag-O-Matics which have also been semiautomated. Although there are variations in these installations, as yet there has been no attempt to place more than two uncured tires ahead of each mold position.

In several of the truck installations the pan-loader principle has been applied. Uncured tires are dropped into a pan at floor level where they are automatically elevated and placed on the loading chucks. The pan then automatically returns to the floor and a second tire is placed in it. Again, it is elevated but does not go onto the chuck until the chuck is empty. This provides two tires in reserve and makes possible the minimum cure for each press and eliminates sequence operation. After the truck tires are cured, they are automatically expelled to the rear of the press onto a take-away conveyer.

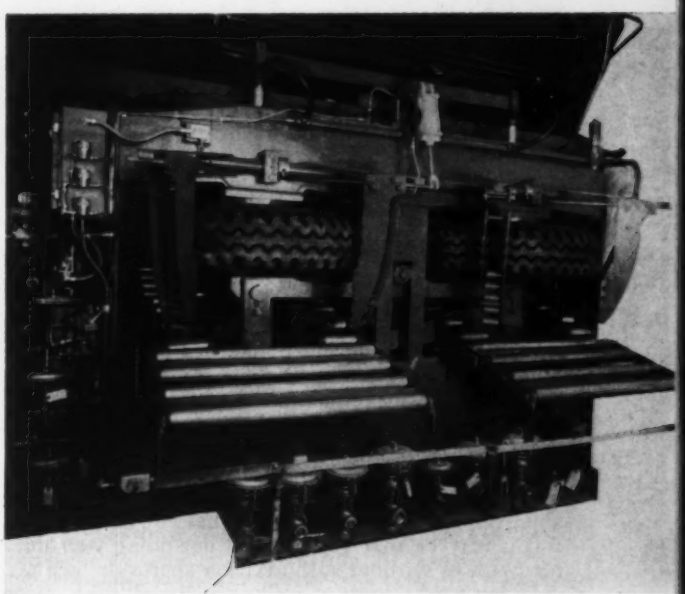


Fig. 8

Post Inflation

The post inflation of tires is also handled automatically. Post inflators are installed at the rear of the press in such a manner that, after the tire is cured, it is automatically discharged into the post inflator, Figs. 7 and 8. After being post inflated, the tire is discharged onto the take-away conveyer.

With the introduction of automation it has been necessary to develop such items as automatic mold blowout, automatic air-blowing of the uncured tire, and automatic mold lubrication.

No one type of loader will fill all requirements and the proper type should be carefully selected for each particular plant and installation.

Fig. 5 The "shuttle pan loader" and service conveyer represent a fully automatic loading method and completely eliminate the operator from the curing room. The clamshells on the conveyer system can be signaled to suit various tire sizes. Flag switches at each mold position cause the correct tire size to drop at the proper presses.

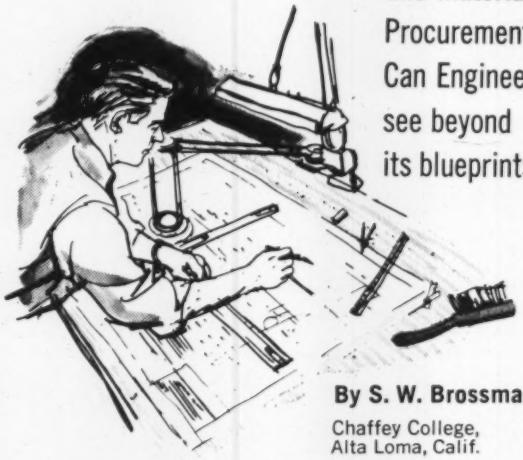
Fig. 6 The shuttle-pan-loader chucks place the tire over the curing diaphragm. The tires come from the building machines to an automatic sorting station with each size on a separate conveyer. The continuously running service conveyer passes over each loading station. At the proper station, the clamshell is automatically opened and the uncured tire is mechanically raised so that the clamshell can close around it.

Fig. 7 Automatic post inflator for passenger-car tires. This unit provides for immediate inflation as soon as the tires are discharged from the press.

Fig. 8 Automatic post inflator for truck tires

Engineering's GLASS HOUSE

How does your Engineering Department rate with Production, Quality Control, Contracts, Estimating, Long-Range Planning, Manufacturing Control, and Material Procurement? Can Engineering see beyond its blueprints?



By S. W. Brossman[1]
Chaffey College,
Alta Loma, Calif.

ONE of the most sensitive areas between Engineering and Production is the no-man's land over which the engineer must crawl in order to make a design change to an item already in production. Production fights any one-and-on[2] changes, for such changes obviously disrupt the manufacturing processes. And Engineering insists on changes which, in its opinion, will make a better, cheaper, safer, or faster product. In order to arbitrate between the reasonableness of the design change and the resistance of the Production Factory to the change, some companies have inaugurated so-called Change Control Boards.

Are Engineers Always Right?

But if your company uses a Change Control Board and your Engineering Department is ready to start throwing stones at it, maybe you'd better make sure that Engineering doesn't live in a glass house. The fact is that, if you have a Change Board, chances are this means that you don't have a system within Engineering to do the design-change housekeeping.

Before the engineer writes a work authorization to make design changes, he should check with other departments to see how their interests are affected. And before Engineering submits change paper to the Change Board, it should insure that the Checking Group has swept it clean of errors. It may be that your own engineering house is not in order or you probably would not have a Change Control Board to begin with.

In theory, design changes should be Engineering's baby from start to finish, but company management may have fixed paternity upon the Change Board because the engineers were not fit parents.

Perhaps your company policy has been evolved because your Engineering Department has not saddled engineers with the responsibility of checking with other departments before they spend money on design changes that may later prove to be impractical. In effect, such a company policy puts a bridle on Engineering, requiring your design change work authorizations to be approved by the Board to insure that you do your duty. But it may be that you are still not doing your duty, for, with or without authorization approvals, you may still be approaching the Change Board with faulty change packages without any previous knowledge of how your design changes affect other departments.

For example, let's say that one of your design engineers decides to double heat-treat a protrusion on a product already in production. He appears before the Change Board, a group representing Production and most of the other internal departments. None of the representatives are nonengineers, yet they object to the double heat-treat process because, they say, "everyone knows" that there is no value of heat-treating beyond the initial stage. The engineer presents the latest technical information in support of his design change request, but he agrees that there is no way to distinguish between a piece of metal that has been single heat-treated and one that has been double heat-treated: they look the same.

The Change Board decides, therefore, that the design change request to double heat-treat can be granted only if there is 100 per cent proofing of each heat-treated protrusion. However, the representative from Estimating then pops up and points out that 100 per cent proofing, plus the cost of double heat-treating all the protrusions on products already fabricated, i.e., one-and-on, would be more costly than merely replacing defective protrusions as they break in inspection.

Fixing Responsibility

Engineering's glass house, therefore, may be vulnerable to attack. And an obvious solution is to give these release responsibilities to the Design-Group supervisors. As it is, the Design-Group supervisor usually points the finger at the Project Office and Change Board; the Project Office blames the Design-Group supervisor and Change Board; the Change Board blames Engineering; and Engineering blames the Change Board.

I nominate the Design-Group supervisor and the Drawing-Check supervisor as the culprits to arraign in the event that other departments are not consulted before design changes begin, or when poorly prepared change packages are sent to the Change Control Board.

[1] Chairman, Language Arts Division.

[2] "One and on" means making the change back to the first product turned out. "Fifteen and on" would mean going back to the 15th item produced.

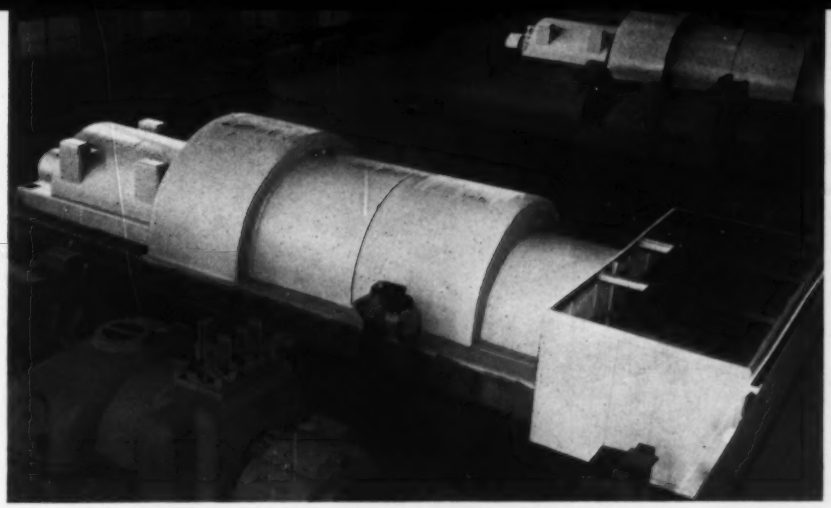


Fig. 1 Two gas turbines were installed between three existing steam turbines. Cost was $3 million less than building a new equal-capacity steam-turbine plant elsewhere. Steam turbines were undisturbed.

These two simple-cycle gas turbines, in a power plant, cost $110 per kw of installed capacity. Now, with their first 1500 hr of fired time on record, we have a report on their performance in service.

By C. H. Stanton,[1] Mem. ASME, **and H. C. Luff,**[2] Assoc. Mem. ASME
Orlando Utilities Commission, Orlando, Fla.

THE ORLANDO GAS TURBINES

In 1958, the Orlando Utilities Commission installed two gas turbines for peaking and standby service. These units were then the largest simple-cycle gas turbines in the United States and among the largest anywhere, Fig. 1. The operating and maintenance experience with these units should be of interest to other users and potential users of large simple-cycle gas turbines.

In 1956, the Commission's generating facilities consisted of three 900-psi, 900-F, 30-mw steam turbines at the Lake Highland Plant, and several 250-psi low-pressure steam turbines with a combined capacity of 15 mw at the Lake Ivanhoe Plant. At that time the low-pressure turbines were used for peaking and standby service. A study revealed that system peak loads from 1952 through 1955 had been increasing at an average rate of 21 per cent per year. As shown in Fig. 2, a load-duration curve for the year 1955 indicated that loads in excess of 70 per cent of the highest annual peak load occurred only 2.5 per cent of the total hours in the year. Power generated at levels above 70 per cent of the highest system peak load accounted for only $^4/_{10}$ of 1 per cent of the total system generation.

It was quite evident that a serious peaking problem existed that would require installation of additional generating facilities by 1958. Condenser-cooling-water limitations and space limitations made installation of additional steam-turbine generating units at Orlando impractical. Two 16.5-mw gas turbines could be installed at the Lake Highland Plant for $3 million less than a new 33-mw steam generating plant located elsewhere. Savings in operating labor and transmission-line losses were estimated at about $140,000 per year for the gas-turbine installation as compared to a remote-steam-plant installation.

As a result of these studies, two 16.5-mw gas turbines were ordered from the General Electric Company in 1956.

Description of Installation

The most economical arrangement proved to be installation of the gas-turbine generators in the Lake Highland Plant between the three existing steam turbines, as seen in Fig. 2. Some steam-turbine auxiliary equipment would require relocation at a cost that was negligible compared with locating the units in a separate building. Motor-driven exciters were decided upon to reduce the over-all installed length of the gas-turbine generators, and removable metal covers were used for the gas turbines to improve appearance.

Piles were driven for the gas-turbine foundations, with the steam turbines in operation, by hanging the pile driver from the plant overhead crane. Space limitations required that air for the units be taken from inside the plant building without using an air-intake filter. A silencer was used on the intake to control the noise level in this area. The air-intake duct was located at the plant-basement elevation and was routed downward across the basement level out through the front wall of the building and upward through steel stacks at the front of the plant and covered with corrugated anodized-aluminum sheets to improve appearances.

The gas turbines were designed to operate on either

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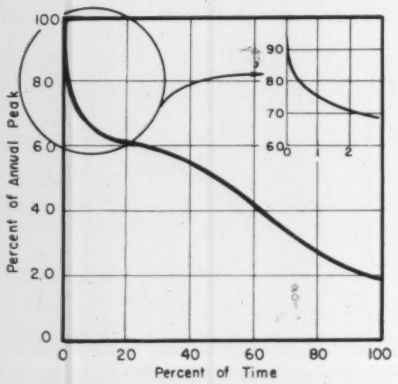
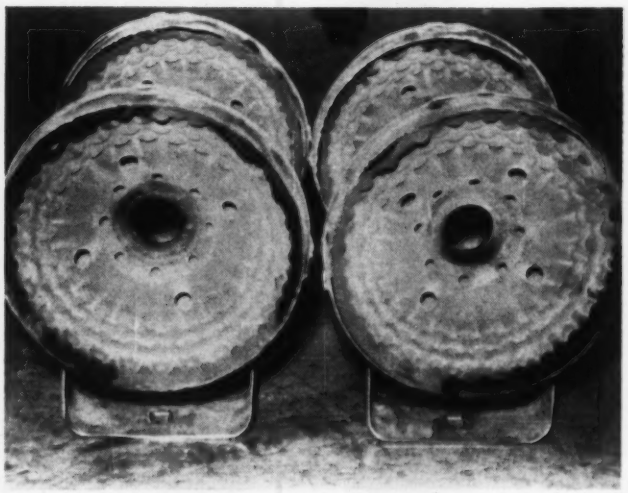
[1] Secretary and General Manager.
[2] Manager, Electric Generation.

Contributed by the Gas Turbine Power Division and presented at the Gas Turbine Power Conference, Washington, D. C., March 5-9, 1961, of The American Society of Mechanical Engineers. Paper No. 61—GTP-6.

ORLANDO GAS TURBINES





No. 2 distillate oil or natural gas with a rated-load heat rate of approximately 16,800 Btu per kwhr. Provision was made for manual transfer between fuels with the unit in normal operation. At rating, the turbine gas-inlet temperature is 1450 F and the turbine-exhaust temperature is 840 F. The unit rating is based on a compressor air-inlet temperature of 80 F. The 15-stage axial-flow compressor is designed for an air flow of approximately 220,000 cfm at 14.17-psia inlet pressure at 80 F, with a nominal pressure ratio of 6:1.

The units were designed for semiautomatic starting, requiring no manual control of the starting cycle from the time the unit rolls off the turning gear until the machine is under control of the speed governor.

The gas-turbine facility was completed in 1958 at a cost of approximately $110 per kw of installed capacity.

Operating Information

The Orlando gas turbines can be started cold and be on the line in 20 min, a highly desirable feature for peaking and standby service. The semiautomatic starting feature of the turbine-control system has enabled the units to be used without adding operating personnel to the plant. They are controlled by the plant steam-turbine operators. When used for peaking service, they average 3 to 4 hr operation for each start. Under these conditions the average heat rate is about 17,400 Btu per kwhr. The gas turbines have been used several times for continuous duty during scheduled inspections of steam-turbine generators and, under these operating conditions, the gas turbines operated at an average heat rate slightly above 16,800 Btu per kwhr.

Because of the extremely poor light-load heat rate of the simple-cycle gas turbine, the units are loaded to rating as rapidly as possible and are unloaded in the same manner. When taken off the line, the speed is lowered to 2700 rpm before the fuel supply is tripped in order to reduce the thermal shock in the high-temperature zone of the turbine.

Both units were placed in commercial operation in December, 1958. Number 2 distillate oil was used exclusively until July, 1959, when gas became available.

Various start-up problems had resulted in a lengthy six-month preliminary testing period on the Orlando B unit. Considerable difficulty was experienced in obtaining proper adjustment of the control equipment associated with the semiautomatic starting cycle. Ignition troubles were caused by the fuel nozzles which were later replaced with improved models. The spark-plug ignition transformers were replaced and relocated at a lower point where temperature conditions were more favorable than when high under the unit covers.

Out of 107 attempts to start the unit during preliminary testing, the machine reached rated speed only 43 times. Unit fired time accumulated during this period was 86 hr. At 74 hr fired time, failure of the unit to cross fire properly resulted in disassembly for inspection of the combustion liners and cross-fire tubes.

Warping, Fig. 3, found on the outer edges of the inner louvered portion of the combustion-liner cap assembly, resulted in liner modifications on both gas turbines. The inner louvered portion of the combustion-liner cap assembly was continuously welded to the cap-assembly body rather than at intervals as originally furnished. Additional holes were drilled in the combustion-liner cap to provide better air distribution in the liner.

The preliminary testing period on gas turbine A was halved as a result of the test experience with unit B. Only 30 hr of fired time were accumulated during this period for gas turbine A. By July, 1959, when gas fuel became available, the combined total fuel-oil-fired time on the two gas turbines was 500 hr. At the time of writing, the A and B units had each accumulated 1500 hr of fired time.

The operation of the fuel governor on these units has been good. Tests have been run in which the units were tripped from a load of 10 mw without overspeeding or losing flame. Under one emergency operating condition, B unit generator circuit breaker was closed on a load of 10 mw with the unit operating at rated speed. The unit held this load and it was possible to return the unit to rated speed and voltage in about 15 sec.

Maintenance

With only 1500 hr fired time apiece, definite routine-maintenance schedules have not been established, or the proper interval for major unit overhaul determined. Some maintenance has been required to keep the control equipment associated with the semiautomatic starting cycle operating satisfactorily. This maintenance work

LEFT TO RIGHT

Fig. 2 Duration of load on the Orlando Utilities Commission system in 1955. Power generated at levels above 70 per cent of the highest system peak load accounted for only 0.4 per cent of the total system generation (as shown by the relationship of the area between the 70 per cent line and the curve to the total area under the load-duration curve). This level was sustained only 2.5 per cent of the total hours in the year.

Fig. 3 Warping was found on the outer edges of the inner louvered portion of the combustion-liner cap assembly when inspection was made after 74 hr of operation.

Fig. 4 Modification consisted of continuously welding the combustion-liner cap assembly to the body, rather than at intervals as originally furnished. Additional holes were also drilled to provide better air distribution in the liner.

Fig. 5 Considerable cracking of the first-stage nozzle was found in the seal welds around the butt ends of the partitions at the inner and outer sidewalls. Dark areas are developed dye in the cracked areas at the outer sidewall. Dye-penetrant inspection was used.

was no more than would normally be expected for this type of equipment, and the work has been carried out satisfactorily by a competent plant electrician under engineering supervision.

Visual borescope inspection of combustion liners at intervals of about 100 hr appears advantageous on a newly started unit. After the first 200 or 300 hr of operation, the inspection interval could be about 400 to 500 hr until a proper inspection interval is determined by experience. Borescope inspection of the combustion liners has been carried out under supervision of the plant mechanical engineer, who has kept detailed records of the condition of the combustion liners. These have required considerable maintenance.

Borescope inspection of the combustion liners on both gas turbines at approximately 1300 hr fired time revealed considerable cracking in the area where the cap and the liner assembly were joined. The cracking was serious enough to warrant immediate repair. New combustion-liner cap assemblies were available but new No. 2 combustion-liner assemblies could not be readily obtained, making it necessary to repair the existing assemblies in the field by welding. The welds were applied to the outside surface of the combustion liner where necessary to join cracked areas, and holes were drilled near the liner cap assemblies for better air distribution, as shown in Fig. 4. After these repairs the gas turbines were returned to normal operation.

Frequent borescope inspection revealed that some cracking was occurring in the areas where welded repairs had been made. At approximately 1500 hr fired time, gas turbine B was removed from service for installation of new modified combustion liners. While the repaired liners in this unit showed some cracking in the repaired areas, the liner condition was considered fairly good. It appears that emergency repairs to combustion liners can be carried out by welding with some success.

At the time of the unit combustion-liner replacement, it was decided that the small additional cost of a complete unit inspection would be warranted. Examination of the compressor rotor gratifyingly revealed no erosion on the compressor blades and only a very light soluble oil film was deposited on several stages of blades at the compressor inlet in spite of the necessary exclusion of a compressor-intake filter. The turbine and compressor bearings were opened for inspection and were found to be in good condition.

Dye-penetrant inspection of the turbine rotor and blades, the upper diaphragms, and the upper section of the first-stage nozzle disclosed considerable first-stage nozzle cracking in the seal welds around the butt ends of the partitions at the inner and outer sidewalls. The dark areas around the partitions in Fig. 5 show the developed dye in the cracked areas at the outer sidewall. The majority of the cracks were in the outer sidewall and varied from 20 to 90 per cent of the length of the weld. This cracking was apparently the result of differential-expansion problems. The manufacturer did not consider these cracks serious enough to warrant replacement or repair of the first-stage nozzle.

All other parts checked proved to be in good condition. After inspection was completed, the unit was reassembled and was tested satisfactorily. Frequent borescope inspection of the new combustion liners will be continued until sufficient operating time shows that these liners are satisfactory, and the progression of the first-stage nozzle cracking will be carefully noted at subsequent inspections.

Conclusion

The quick-starting ability of the Orlando gas turbines has made them ideal for peaking and standby service. The problems that have been experienced have been no more than would normally be expected in any new class of large equipment of this nature. Operation has been generally satisfactory and the units have economically fulfilled a definite requirement.

Academic research must furnish results of a general and lasting nature that go beyond a temporary, practical objective. The methods and principles developed in engineering research may be valuable long after the problem has been outgrown.

University RESEARCH IN

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MODERN engineering is so closely connected with the mathematical-physical sciences that academic research and postgraduate work in engineering must be pursued in closest relation to these sciences. Since postgraduate and research work began earlier in the mathematical-physical sciences, it seems natural to apply standards of quality developed for these sciences to corresponding work in engineering. This application of similar standards sometimes discloses a conflict in opinion between engineers and representatives of the mathematical-physical sciences as to what constitutes acceptable research. This conflict does not exist between "engineering science" and the mathematical-physi-sciences, since engineering science is a part of these sciences. The conflict does appear whenever the *application* of the scientific principles to engineering problems plays a decisive role.

The proposed solution of this apparent conflict is based simply on the fact that engineering is *applied* science (similar to medicine), and not just applicable science. Engineering is therefore understood to include application as an essential element.

In accepting this definition of engineering it is obviously meaningless to object to applied research in engineering unless it is desired to object to engineering itself as a subject for graduate study. The problem is to determine whether the element of application is detrimental to the standards of quality in engineering research at a university.

Although the element of application has often led to superficial and thereby unacceptable work in engineering, it will be shown that this same element of application, if properly recognized, is actually valuable for maintaining high standards of quality, and for the establishment of engineering as an important discipline of human activities. Application is not merely to be tolerated, but should be cultivated for what it really can mean, lest a loss of the creative element in engineering so badly needed in today's world is invited.

The Origin of Engineering Problems

In discussing the problem and its solution, it is necessary to introduce a philosophical difference between engineering and the mathematical-physical sciences. The distinction used here is that of motivation: the scientist wants to *know* something not yet known; the engineer wants to *do* something not yet done. This distinction applies here to the physical world, in contrast to philosophy, law, and similar disciplines. It may thus be said that the physical scientist wants to *know* this world and the engineer wants to *change* something in that world. This distinction, of course, does not apply to individuals in accordance with their academic degrees as many chemists and physicists are engineers by this definition, and many engineers are scientists. The same person may work or think sometimes as an engineer and sometimes as a scientist according to his aims under par-

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ticular conditions. Thus the foregoing distinction in motivation is being used as a definition for the words "scientist" and "engineer," mainly for lack of a better definition of these controversial terms.

It follows that there must be a difference between the physical sciences and engineering regarding the *selection* of problems to be investigated.

With some idealization it can be said that the scientist selects his problems primarily by their logical relationship to the existing state of work and knowledge in his field. While such relationships must also be observed by the engineer, his *problem selection stems primarily from the requirements of some practical development to be accomplished*.

At this point it is necessary to avoid a specific misunderstanding: An engineer's practical problems are by no means always dictated by demands outside his influence. The selection of *what* is to be accomplished is as much a task of the engineer as *how* it is to be accomplished. The Wright brothers certainly were not asked to fly; more likely they were asked *not* to fly. If their primary idea was to find out whether or not it was possible to fly, their motivation was that of a scientist. If they just wanted to fly (period!) then their motivation was that of an engineer—although they certainly used available scientific tools to accomplish their goal and in doing so made contributions to scientific knowledge.

Characteristics of Engineering Problems

After considering their origin, one finds a few general characteristics of engineering problems that are believed to be of importance for this study.

The requirements of some practical development to be accomplished may lead frequently to problems that fall outside the logical path of scientific work in the field concerned, that is, the problem that must be solved may not be one that would have been selected on purely scientific grounds.

Because of this, it is often necessary for an engineer to attack problems with *incomplete background knowledge*. The case is sometimes analogous to that of a surgeon who cannot let his patient die just because he does not understand the nature of the disease. While in reality the scientist must often do the same, he might not choose to do so if working ideally on a "pure" research problem.

Second, engineering problems are involved with the element of *time* to a greater degree than those of the mathematical-physical sciences. Most engineering problems may be expected to become trivial or their solution worthless in one or a few decades. The time that can be devoted to their solution is usually limited in a manner not prevailing to the same extent in the mathematical-physical sciences.

The afore-mentioned limitations of engineering research are often considered as detrimental to the quality of academic research in engineering. However, these very characteristics and limitations can be used to increase the scientific value of engineering research because:

1 The necessity of attacking problems lying outside the natural path of scientific research stimulates consid-

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eration of *new problem areas*. For example, most recent investigations in fluid mechanics have been prompted by practical problems in aeronautics and astronautics.

2 The necessity of attacking problems with incomplete background knowledge demands very orderly thinking and procedures in a complex situation. The field of operations research is an example for this effect of practical requirements on scientific discipline. The rare ability to handle such situations logically and effectively must be regarded as an essential goal for higher education in engineering.

3 The limitation in time, so often deplored as a disturbing element in research, demands careful *selection* of a limited number of significant and tractable subproblems that can be solved to the required degree of accuracy within the time available. This selection of subproblems requires scientific and practical judgment, a vivid perception of the physical nature of the over-all problem, and a dependable knowledge of the scientific methods available for the solution of each subproblem. Again, the type of thinking required is regarded as essential in higher education for engineers.

It appears that apparently detrimental elements in engineering research can have very stimulating effects on the underlying sciences and on scientific thinking in general.

Pitfalls and Requirements

Superficial research in engineering is too often defended on the basis that "there was not enough time (or money) for a thorough investigation."

Representatives from the physical and mathematical sciences will agree that thoroughness is an essential criterion of quality in research. Thoroughness is not completeness, as no scientific work is ever complete. It does imply such qualities as systematic procedure, the proper use of available knowledge, and a high level of intellectual curiosity and discipline.

Fortunately, *thoroughness* is found to be a prerequisite for effective research in engineering. No work at all is usually preferable to superficial work.

Experience has shown that superficial research work is both wasteful and dangerous. It is wasteful because at best its results will apply to one particular situation, requiring a repetition of the entire work for applications under slightly different conditions. It is dangerous because incorrect application of the results, resulting from incomplete understanding of their meanings or limitations, usually leads to unexpected failures. Thoroughness is therefore justified on practical grounds alone.

In addition to thoroughness and understanding, academic research in engineering must furnish results of a general and lasting nature that go beyond a temporary, practical objective. If the work of a university laboratory were to lose all value because practical objectives changed or vanished, it could be argued justly that the laboratory did not fulfill its obligations as an academic institution. The *methods* and *principles* employed and developed must stand scrutiny and repeated application for many years after the original, practical purpose of the work has been forgotten. The theft of gold in repairing the crown of Syracuse was hardly a noteworthy historic event, but the way in which Archimedes discovered it will not soon be forgotten.

Thus it appears that not *what* is done, but *how* it is done, determines the academic value of engineering research.

"Basic" and "Applied" Research

It must be admitted that research in engineering has often failed to satisfy the minimum requirements of thoroughness and background knowledge necessary to achieve its practical objectives and recognition from serious engineers and scientists. As a consequence, the familiar distinction between "basic" and "applied" research has come to denote a difference in scientific quality. While applied research to be effective must meet the highest scientific standards, it should be recognized that much is yet to be accomplished before engineering research uniformly attains these standards. This is of decisive importance not only for immediate practical results, but also for the future of such research. At present many of our most promising young engineers shy away from "applied" research simply because of their desire to be connected with research of high scientific quality. If these qualities are not practiced in engineering research, our young PhD's in engineering may not realize what *good* applied research can and must be.

Summary

1 Engineering research is applied research. Application is an essential element of engineering, to be recognized and cultivated in university research for its true value and significance.

2 Superficial work in engineering is wasteful and dangerous. Thoroughness of procedure and understanding of results are a practical necessity in engineering research as well as a criterion of scientific quality.

3 Engineering research often involves problems lying outside the path of normal scientific advancement. Thereby it stimulates the investigation of new fields of physical knowledge and scientific discipline, and demands methods of orderly procedure under complex conditions and with incomplete background knowledge.

4 University research in engineering must advance knowledge and thinking independently of the temporary practical value of the results obtained. Not *what* is done but *how* it is done determines the academic value of engineering research.

This second installment covers gear lubrication, rolling-element bearings, fluid-film bearings, and lubricant properties. Discoveries in the past few years have led to new theories and new applications.

LUBRICATION REVIEW

Gear Lubrication

By M. Godet[6]

THE 1959–1960 contribution to gear-lubrication literature can be listed under the following headings: The lubricant as a gear-design parameter, relaxation phenomena in gear lubrication, gear lubricants evaluation, investigations with gears and disks, and film-thickness measurements.

The Lubricant as a Gear-Design Parameter. Blok [265][7] states that, as a gear tooth cannot carry more load than its beam strength will allow, all lubrication failures may be conveniently compared to the beam-strength criterion. For homologous gears (that is, geometrically similar gears of the same material but of different sizes), expressions for performance barriers limited by tooth breakage, metal-to-metal contact, pitting, and scuffing are obtained from manipulations of equations developed, respectively, from beam strength, minimum film thickness (Grubin), Hertz stress, and flash-temperature theories. These expressions are: (*a*) For tooth breakage—$P_b = C_b n l^3$, (*b*) for pitting—$P_p = C_p n l^3$, (*c*) for tooth contact—$P_c = C_c n^9 l^{14}$, (*d*) for scuffing—$P_s = C_s n^{1/7} l^{9/7}$, where n and l are, respectively, the speed and a characteristic linear size of the gears and where C_b, C_p, C_c, and C_s are constants which are to be determined for the class of homologous gears and the lubricant considered. A graphical representation of the relative position of each barrier can be obtained by plotting for a given gear ($l = l_0$) the power transmissible as a function of speed for various barriers, and for a given speed ($n = n_0$) the power transmissible for various size gears. From these plots it is possible to see, after a determination of the constants of the equation, what kind of performance barrier will first be met in a given gear operation.

J. F. Osterle [266] notes that, in applying the hydrodynamic theory to the problem of gear lubrication, previous authors have approximated the geometry of gears with disks; these in turn are approximated in the region of contact with parabolic arcs. The first approximation does not take into account the squeeze effect introduced in gears by the variation of the radius of curvature with time. The solution developed by the author for the film thickness is in the form of a series. The first term gives the expression for the parabolic-arc theory, thus the second term of the series can be regarded as a first-order correction. This correction shows that for external gears of equal size the first-order correction is nil. For gears of unequal size the correction grows as the size difference grows. The correction increases the maximum pressure and the load-carrying capacity when the pinion is driving and decreases them if the pinion is driven. The maximum increase is 4 to 1.

Relaxation Phenomena in Gear Lubrication. Discoveries in the past few years about the relaxation behavior of oils have led to much speculation about the part played by this phenomenon in lubrication. G. J. O'Donnell[267], in a review on this subject, discusses relaxation and outlines some of the difficulties inherent to a study of the subject. He points out that it has been postulated that the increase in load-carrying capacity of gears with an increase in speed could be explained by relaxation effects, as the Hertzian contact times in high-speed spur gears are of the same order of magnitude as the relaxation times of the lubricants. This is disputed by Crouch and Cameron [268] who in an analytical study of the problem suggest that the effect of relaxation is not as great as has been believed, and that the increase in load-carrying capacity could be explained by a decrease in the rate of change of oil viscosity with temperature. This conclusion is based on empirical viscosity calculations per-

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[7] Numbers in brackets designate References at end of paper.

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The "Digest of 1958 Literature" on lubrication appeared in MECHANICAL ENGINEERING, October, 1959, pp. 56–69.

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formed for the conditions found in Borsoff's [269] data. Gatcombe, et al. [270], making up for an omission in gear literature, outline calculation of contact times.

Gear-Lubricants Evaluation. In attempting to obtain a correct evaluation of gear oils, authors are limited at this juncture to the study of the correlation between bench-test results and full-scale gear tests and field performance. While it can be hoped that any particular correlation might hold for oils of similar nature, it is too much to expect it to be valid for a broad range of lubricants. The lack of agreement between bench tests further adds to gear-evaluation problem. Some authors suggest that the failure criteria are to blame for this lack of agreement more than the bench tests themselves. Elliott, et al. [271] argue that with carefully defined failure criteria the 4-ball and the SAE machines might be used to predict the performance of lubricants in L-42 and L-37 tests, as they can be made to exhibit, respectively, the scoring and ridging failures associated with those tests. According to the authors, the correlation obtained from the 4-ball machine is good, and while the results from the SAE machine appear promising, are not conclusive.

Confronted with the same problem, De Ardo and Sargent [272] compare the relative evaluation of gear oils by Falex, Timken, and 4-ball machines. A Mil-L-2105 oil was used as a reference oil and 10 runs were performed on each machine. The failure criteria were the failure load for the Falex machine, the maximum safe load and safe unit pressure for the Timken, the scar diameters at various loads, and the seizure loads for the 4-ball machine. From these results, rating tables were developed to obtain 95 per cent confidence level. The results from these machines are not given equal weight in the final evaluation. This is an effort to correlate the results of three bench tests for different oils.

Schultze, et al. [273], concerned primarily with machine-gear lubricants, and dismayed by a lack of agreement between various bench-testing machines, have derived a test of their own known as the IfE tester. In this machine a loaded arbor is rotated against stationary cylindrical pins. The scar on the pins gives a measure of wear. The authors report on the effect of running-in conditions, oil supply, sliding velocity, temperature, and additives upon wear measured in the IfE tester.

In a review of gear rigs, Ryder [274] discusses scuffing, pitting, and fatigue. Particulars of the IAE, Thornton, FZG, Shell Development, Ryder, and Western Gear machines are included. The author emphasizes that valid results can only be obtained with gear rigs if the failure criteria are carefully defined.

The necessity of using rigorous testing conditions for gear rigs has been recognized in Great Britain [275] where new specifications to determine the load-carrying capacity of lubricants with the IAE machine have been incorporated in new British test method IP 166/60-T, superseding test IP 166/58-T.

In a study of the behavior of lubricants under specific environmental conditions, Neely [276] warns that lubricants irradiated under static and dynamic conditions do not behave in the same way. He showed that the degradation obtained by testing oils in a gearbox under radiation was very much more severe than that obtained in the static case.

Also studying environmental effects on lubricants, Meckel and Quillian [277] report that the results obtained in their investigation of thermal-oxidation stability of lubricants using a gearbox instead of the usual glass apparatus correlated well with field-test results.

Investigations With Gears and Disks. Borsoff, Ku and Baber, Hughes and Waight, and Smith report on some experimental data gathered with spur-gear machines. Types of gear failures are discussed and the effect of various parameters on gear performance is mentioned. Borsoff [269] singles out abrasion, scoring, and chemical corrosion as three wear mechanisms directly influenced by the lubricant. By testing gears of different geometry at different speed, he shows that the increase in load-carrying capacity, LCC, with larger-diametral-pitch gears is less pronounced at high speed than at low speed; that tip relief increases the LCC, up to a point; that the degree of surface finish affected the LCC; and that LCC is not directly proportional to gear width. Higher specific loads in pounds per inch of face were obtained with thinner gears. Among operating variables the effect of temperature, flow rate, oil-nozzle position, and speed was investigated. The data suggest that there is a definite relationship between LCC and the viscosity for lubricants of similar nature. Feeding the lubricant just before mesh gives the best results. Higher oil flow rates gave higher LCC. The LCC first decreased with speed and then increased to very high value. It was lowest for a speed of 5000 rpm. Relaxation effects discussed earlier are suggested as an explanation for this.

Data on the effects of speed, load, and time on wear using radioactive techniques were also presented. The wear patterns obtained from straight mineral and EP oils are markedly different. For straight mineral oils the wear is instantaneous and caused by scoring. For EP gear oils, wear is much lower and gradual and caused by chemical corrosion. The author concludes by saying that hard-steel spur gears operate in two zones of lubrication—in one the meshing teeth are separated by a thick lubricating film, in the other the separating film is of boundary or extreme-pressure nature.

Ku and Baber [278] running parallel experiments with a Ryder gear tester confirm Borsoff's results concerning the effect on the load-carrying capacity of different oils, of viscosity, gear speed, lubricant supply, and lubricant temperature. They have further run tests on new and deteriorated oils (that is, oils at 210 F in which air has been bubbled through a copper tube with occasional addition of water) and report an increase in load-carrying capacity for the treated oil, unfortunately accompanied by undesirable side effects. In running experiments with inert atmospheres, a large increase (up to 100 per cent) in load-carrying capacity was noted; both argon and nitrogen were tried with little difference between them.

Hughes and Waight [279] compare their results obtained with an IAE spur-gear machine with the theoretical treatments of Blok, Almen, and others. By studying the effect of the viscosity ν, the speed N, and the bulk-oil temperature θ, on the load-carrying capacity, they found that the data could be fitted by an expression of the form

$$W = \frac{K(\nu)^{1/2}}{N^{0.4}e^{a\theta}}$$

where K and a are constants to be determined.

It is worth noting that they did not observe a reversal

in the downward trend in the load carrying of lubricants with an increase in speed as did Borsoff, and Ku and Baber, even though some tests were run at speeds of 12,000 rpm. The effects of additives and of additive concentration on the type of failure are also discussed.

Reviewing some of the problems currently under investigation at WADC, Smith [280] reports that the effects of lubricants and of operational variables on gear fatigue are being studied in the Ryder gear rig using gears with a tip relief of 1.6 mils. Viscosity is shown to have little effect on fatigue, and, according to the author, no correlation can be drawn between oils of high load-carrying capacity and oils which give long fatigue life.

Shipley [281] outlines the problems associated with high-temperature gear operation from both the lubricant and the gear-material point of view. Oxidation and thermal-stability tests were performed for 45 different oils, and spur-gear tests were run on those which held promise. In the study of gear materials, the author reports that above 350 F ordinary case-carburized gear materials are no longer adequate. Some of the properties that high-temperature gear materials must embody include high fatigue strength, high hardness, good resistance to scoring, good machining, and no age embrittlement. Many high-temperature materials were screened and tested for fatigue, hardness, and impact strength at high temperature. Nitrided materials gave, on the average, superior performance over ordinary hardened steels.

Attia [282] studied dynamic loads at different speeds in gears by measuring the deflection of spur-gear teeth with a strain gage used as an extensometer. The author found that the position of maximum dynamic load varies with operating conditions; that the strain in the body of the gear causes the tooth to deflect even before it comes into mesh; and that the maximum dynamic loads occurred during single-tooth contact. The dynamic loads observed are lower than those calculated from Buckingham's theory.

Kohler [283] made similar measurements using barium-titanate crystal gages installed on the gear blank between two gear teeth. The signal-to-noise ratio of such a system is very favorable and interference from slip-ring noise is reduced. Niemann and Rettig [284] studied tooth deflections due to errors in base pitch of the gears using an inductance extensometer placed on the side of the gear. The records obtained show that, after initial impact, the displacements are in the form of vibrations superimposed on the static-deflection curves. The authors calculate that these vibrations occur at the natural frequency of the tooth spring and gear-mass system.

Misharin [285] investigated the effects of changing sliding and rolling conditions on the coefficient of friction. Two disks of 60 and 90 mm in diameter with a contact width of 8 mm were used for the tests. Sliding velocities up to 12 mm per sec and total rolling velocities up to 23 mm per sec were obtained for the experiments. No influence of the disk material upon the coefficient of friction was established. The coefficient of friction stayed constant for contact stresses up to 7000 kg per sq cm and increased slightly beyond that. For a constant sliding velocity, the coefficient of friction decreased as the total rolling velocity increased, and for a constant total rolling velocity it decreased with an increase in sliding velocity. The coefficient of friction also increased with an increased disk surface temperature. Misharin states that the results obtained here agree qualitatively with the contact hydrodynamic theory of Petrusevich.

Both Misharin and Watson [286] state that disk machines do not effectively differentiate between oils of differing viscosities. Using an SAE disk machine, Watson reports that, for a given specific sliding, the load-carrying capacity and the coefficient of friction decreased with increases with sliding velocities. This held true for many types of oil. Also the coefficient of friction decreases slightly with an increase in load and varies with the disk material.

Also using a disk machine, Shotter [287] examines the effect of surface finish on gear-tooth performance. The tests were not run to establish a trend between load-carrying capacity and surface finish, but to study the torque necessary to drive specimens of different finish and perform metallographic inspections after runs performed under normal (that is, not unusually severe) operating conditions. Seven grades of surface finish were tried from a very coarse turned surface with a surface finish of roughly 0.001 in. to a very smooth polished surface finish of less than 10 microin. Turbine oil at 50 C was used as the lubricant. Surface speeds of the disks were, respectively, 25.8 and 33.8 fps. Film-thickness resistance was measured during operation. The author concludes that, both with respect to friction and electrical resistance, a smooth initial finish possesses an advantage that it never loses.

Straub [288] argues that, as shot-peening increases the beam strength of the tooth, gears of larger diameter pitch can be used where otherwise tooth breakage would occur. As scoring is lighter for gears with small diametral pitch, shot-peening indirectly helps overcome scoring in gears. J. W. Dern [289] discusses the problems of high-speed gears from a gearbox designer's point of view. Frederick and Newman [290] describe gear failures associated with aircraft, marine, and the automotive industry. Clark [291] points to the complexity of the problems of gear lubrication and reviews common types of gear failures. In his study of the importance of good surface finish, he differentiates between two types of undulations commonly found in gears—undulations of small wave length associated with any cutting process, and those of larger wave length which are due to day and night changes in temperature which have occurred during the hobbing operation. Hundere [292] gives a comprehensive review of the problems of gear lubrication and briefly touches on both the theoretical and experimental theories or explanation suggested to account for the load-carrying capacity of gears. Gear failures and the cause of their failures are discussed. Hardy [293] reviews mechanical failures that occur in small mechanisms.

Oil-Film Thickness Measurements. Developments of techniques for the measurements of oil-film thickness between gear teeth and rollers have been reported. Crook [294] reviews the advantages of and the results obtained with the capacitance method described in an earlier paper. El-Sisi and Shawki [295] use the resistive technique for oil-film measurement, using from 1 to 4 per cent of sodium petroleum sulfonate in Castrolite, a 20 oil, which renders the oil conductive. Film thicknesses between rolling

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and sliding disks were measured with this technique. The authors report that the film thickness increases for pure rolling conditions with an increase in oil viscosity, and decreases with an increase in both oil temperature and applied loads. The coefficient of friction increases with increased sliding and increased loads.

MacConochie and Cameron [296] have measured the oil-film thickness between meshing gear teeth on the evidence that when a constant current is passed between two surfaces separated by an oil film the voltage breakdown is proportional to the film thickness. The work was performed on a 5-in-center gear machine using gears with 0.001 and 0.003-in. tip relief and combinations of 19/40 teeth and 30/30 teeth. One of the shafts of the gears was electrically insulated. The results of the test show that there is a considerable thickness of oil (roughly 10^{-4} in.) at the pitch point and that it is independent of load. There is some evidence of contact at the tip and the root of gears. The oil-film thickness increases with viscosity and decreases with load.

Continuing work done on shock loads in heavily loaded rear axles, Powell and Barton [297] use strain gages to measure dynamic torque on the axles of vehicles with four different axles. Sliding velocities based on the sliding at the mean radius of the ring gear were computed for each case. From these calculations, it is shown that increases in pinion offset and gear ratio both tend to increase the sliding velocity of hypoid gears. Gear loadings were obtained during actual operation of an M-37 and an M-211 Army truck running under high-load conditions. Shock loads of over 10,000 lb per inch of face were recorded during gear shifts. The sliding velocity at that point was 7.4 fps.

Nelson and Valentine [298] underline the major differences existing between transmission and rear-axle lubrication requirements. Loads transmitted, operating temperatures, rolling and sliding velocities are different in each case and thus call for different lubricants. Rear axles further have higher load-carrying-capacity requirements as they see both the engine and the transmission torque.

G. Maurer [299] reports on research done on the lubrication of heavy-duty open gearing. Splash, pressure, and intermittent lubrication techniques are discussed. Various lubricants were tested in the following manner. Large gears were covered with lubricant, operated and checked for film breakdown. Lead-napthanate-base lubricant showed an increase in endurance with viscosity. The endurance of grease films was independent of grease hardness. Residual-base lubricants with EP additives show an increase in endurance with an increase in viscosity up to 3000 ssu at 210 F.

Rolling-Element Bearings

By William J. Anderson[8]

ROLLING-element bearing literature generally reflected existing problem areas. The subject matter of published works could be divided into several broad classifications: (*a*) Dynamics and kinematics, (*b*) elasto-hydrodynamics, (*c*) materials and designs, (*d*) lubrication, (*e*) fatigue, (*f*) high temperature, (*g*) vibration and noise, (*h*) torque characteristics, (*i*) special topics.

Dynamics and Kinematics. Reichenbach [300] studied the friction of balls rolling between flat plates and in V-grooves and concluded that the spinning action of the ball on a bearing race should account for the major portion of the power loss in a thrust-carrying ball bearing. A method for obtaining a general solution defining the loading and attitude for each rolling element of each bearing in a system of any number of bearings is presented by Jones [301]. Elastic yielding of the supporting structure as well as centrifugal and gyroscopic loading of rolling elements is considered in Jones' solution which makes more accurate life estimates possible. In another paper Jones [302] discusses the approach to the general solution of the load distribution within a ball bearing and for a multiple-bearing system. Ortman [303] discusses bearing-equilibrium equations and axial and radial-yield rates. The various factors which enter into rolling friction are discussed by Drutowski [304]. Ball-bearing problems such as deflections, torque, and anisoelasticity are reviewed by Cherwin [305] relative to their use in gyros. Johnson [306] presents an experimental investigation of slip patterns in elliptical contact areas and the effect of elastic compliance on the frictional spinning moments.

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Collectively, these papers advance our knowledge of why ball bearings behave as they do by providing information on the basic mechanism of rolling friction, the effects of spinning in the contact area on friction, and on the latest solutions of the equations describing the dynamic behavior of ball-bearing components.

Elasto-Hydrodynamics. The subject of elasto-hydrodynamics, of extreme importance in the analysis of rolling-bearing lubrication, received some attention during the period. El-Sisi and Shawki [307] present film thickness and friction data for two cylindrical disks in rolling contact with various degrees of sliding. Johnson [308] reviews the various elastic-contact stress problems for different types of relative motion and the solutions obtained in two and three dimensions. The pressure distribution in the lubricant-film separating rollers has been computed for a Newtonian fluid and for a Maxwell fluid by Burton [309]. Burton found that shear elasticity can have effects of first-order significance.

Materials and Designs. Research on bearing retainer and race materials was the subject of several papers. Wagner and Burwell [310] found that several heterogeneous alloys containing silver as a soft low-shear-strength phase showed wear properties superior to currently used standard retainer materials. The effect of retained austenite in the structure of SAE 52100 steel on rolling friction, contact plastic deformation, and elastic limit was determined by Drutowski and Mikus [311]. In general, they found plastic deformation to increase with the amount of retained austenite. In measuring the elastic properties of their test materials, they found an inversion between elastic limit and hardness. A further interesting aspect of their work is that plastic flow seemed to

correlate with elastic limit at low stress levels and with hardness at high stress levels. Elsewhere in this review, papers demonstrating a correlation between hardness and rolling fatigue life are reviewed. Recent developments in bearing-race and retainer design and experimental work on bearing-retainer materials are presented by Sutton [312].

Lubrication. The lubrication of bearings with both conventional lubricants and nonconventional lubricants such as dry powders is the subject of several papers. Grease lubrication and the choice of oil viscosity for oil lubrication are discussed in [313]. Data on the effects of radiation on synthetic and hydrocarbon oils and the lubrication of antifriction bearing with solid lubricants are presented by Marles [314]. Jost [315] discusses the use of molybdenum disulfide as an aid to mounting, running-in, and lubricating antifriction bearings. Booser [316] reviews developments over the past decade in new compositions and application practices for greases for ball and roller bearings. Sasaki, et al. [317] found that oil-mist lubrication of tapered roller bearings lessens friction considerably when compared to oil-jet lubrication. A theory concerning friction moment and temperature rise is deduced and found to agree moderately well with experimental results. In another report on cylindrical roller bearings Sasaki, et al. [318] present an analytical treatment of grease lubrication of a cylindrical rolling contact in which the grease is assumed to be a Bingham fluid. Expressions for pressure distribution, volume flow, load capacity, and friction are developed and the shape of the zone in which no flow occurs is defined.

Fatigue. Work on fatigue is reported by several researchers. Milne and Nally [319] used a fatigue tester patterned after the modified 4-ball machine to obtain data showing that pitting is influenced both by the nature of the contacting surfaces and the inherent properties of the specimens. Baughman [320] found that the fatigue life of M-50 steel increased with increasing hardness, decreasing surface finish, and increasing grain size. Lohmann and Schreiber [321] conducted experimental investigations on the load-life exponent and found them to be 3 for point contact and 4 for line contact. Schreiber and Ulsenheimer [322] present a thorough summary article on rolling fatigue which discusses the factors affecting fatigue and two fatigue theories. Carter, et al. [323] found that the fatigue life of four high-temperature tool steels increased continuously with hardness. No correlation was found between fatigue life and elastic properties such as elastic limit. Carter and Zaretsky [324] studied the effect of stress, temperature, and lubricant type on the fatigue life of a crystallized glass ceramic. An inverse-12th-power relationship between stress and life was found and life at 700 F was about $^1/_3$ that at room temperature. Akaoka and Hirasawa [325] conducted fatigue tests with two rollers rolling with various degrees of sliding. Sliding in the direction opposite to rolling decreased fatigue life, and sliding in the direction of rolling increased life compared to pure rolling. The effects of sliding in the contact zone on rolling fatigue are of extreme interest at present because of the poor fatigue performance of many high-contact-angle ball thrust bearings. Sliding is believed to be detrimental to rolling fatigue, but to date no research on this problem has been published.

High Temperature. Many problems still remain to be solved in the high-temperature-regime area. Bisson, et al. [326] describe lubrication studies to 1000 F with both sliding-friction apparatus and small ball bearings. Experiments with electric-motor ball bearings equipped with carbon retainers running at 500 C are reported by Bowen [327]. Glaeser [328] describes life tests of two types of roller bearings with two oscillation amplitudes. Schuller and Anderson [329] studied the effect of load, speed, and temperature on the actual oil-flow requirements of ball bearings at DN values to 1 million. MacKenzie [330] discusses race and separator materials suitable for temperatures to 1000 F, and promising high-temperature lubricants. The development of tool-steel and cermet roller bearings for unlubricated use at temperatures to 1500 F is reported by Westmoreland and Hanifin [331]. McMullan [332] discusses both race and retainer materials suitable for various temperature ranges up to 1500 F. Air Force-sponsored research and development work on high-temperature airframe bearings and accessory bearings for −65 to +1200 F operation are summarized by Hanlon [333]. Johnson [334] reports fatigue-test results obtained with ball bearings operating submerged in a silicate ester at 450 F. AFBMA-predicted lives were obtained. Anderson and Bisson [335] present research results on mist-lubricated ball bearings, dry ball bearings, and gas bearings. White [336] reports endurance and friction data for 20-mm-bore bearings lubricated with saturated felt rings at 10,000 rpm and ambient temperatures to 400 F. Wearing or breaking of the separator was the most common cause of failure.

Vibration and Noise. Vibration and noise were the subject of five papers. Morrison and Tallian [337] describe a method of vibration-spectrum analysis for selecting quiet bearings; surface waviness is correlated with bearing noise. Tallian, et al. [338] discuss the use of a velocity-type pickup for analyzing bearing noise and material heat-treatments for maximizing resistance to plastic flow. Hay [339] describes a resonant-frequency method of determining ball-bearing preload. Igarashi and Iida [340] have analyzed the axial vibrations of small ball bearings and have developed a method for calculating the frequency on the basis of the theory of elasticity and nonlinear vibration. Igarashi [341] carried out an experimental investigation of ball-bearing noise in which the noise was found to be due mostly to vibrations of the outer race which include radial and axial bending.

Torque Characteristics. A study of the torque characteristics of small, grease-packed ball bearings was made by Lawrence [342]. Experimental and theoretical data on the kinematic torque of gyro gimbal bearings are presented by Antrim [343].

Special Topics. In the category of special topics, Wood [344] describes the use of an electronic bearing analyzer which identifies unserviceable bearings by locating the position and size of flaws, whether on the outer race, inner race, retainer, or balls. The analyzer is also said to be capable of indicating relative torque, surface finish, and the presence of contaminants in the lubricant. Lane, et al. [345] describe the Rotorace gyro-bearing system which reduced gyro drift rate by an order of magnitude compared to conventional precision gyros.

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Fluid-Film Bearings

By F. W. Ocvirk[9]

Much of significance and interest appeared on fluid-film lubrication research in a period of high mathematical activity accompanied by great productivity from the digital computer. More than the usual number of solutions of the Reynolds equation appeared for a variety of bearing-film configurations and conditions including compressibility, cavitation, turbulence, variable viscosity, and dynamic loading. Experimental activity during this period, while not as great as the mathematical activity, served to confirm theoretical assumptions in many areas. In general, a high volume of useful data appeared for bearing designers.

Partial Journal Bearings, Cavitation. The challenging mathematical problem of cavitation in oil films has been ably explored in a series of papers by Jakobsson and Floberg [346] who have contributed equations describing mathematically the continuity of flow at the boundaries surrounding the oil and gas strips observed in ruptured films. In their latest paper, design data including the effect of cavitation are given for the partial bearing. Another paper by Floberg [347] gives data for the journal bearing with axial side grooves and includes cavitation effects. Earlier papers by Cameron and Wood [348] on the full journal bearing and by Raimondi and Boyd [349] on the partial bearing have been of interest in that they arbitrarily assumed the cavitated region to be at ambient pressure. In a recent paper, Floberg [350] agrees that such an assumption may be valid because air in an oil film may be expelled in the ruptured region to eventually equalize pressures to the ambient value. He also shows by examples of films in partial bearings that cavitation influences the pressure distribution in the uncavitated film but that the effect on load capacity is slight. However, on the basis of his experimental findings on the influence of cavitation on friction and power loss, Floberg [351] shows that calculation of friction in the cavitated film is nearer correct than using the assumption that the ruptured region is either a full oil film or an air film.

Using the assumption of ambient pressure in the ruptured film, Raimondi [352] presents mathematically determined data for the finite 120-deg partial bearing with the load acting in an arbitrarily oriented direction departing from the simpler loading with the load line bisecting the 120-deg arc. His curves of journal loci show that loads offset in the direction of rotation give superior performance to those oppositely offset. Jacobson and Saibel [353] investigate the fitted partial bearing for which they present an exact mathematical solution for both the finite and infinite cases and determine numerical data on the load capacity and friction of 60 and 120-deg bearings.

Films Between Rolling Cylinders. Particularly interesting in connection with cavitation boundary evaluation is Floberg's paper [354] on the theoretical load capacity of an incompressible, infinitely wide film between a rotating cylinder and a moving flat surface. He shows that the load capacity is reduced as the extent of the film in the in-flow wedge is reduced, showing steep reductions as this extent approaches zero. Srinvisan [355] applies Floberg's technique to the film between two rotating cylinders and finds that the result is the same as Cameron's solution [356] for load capacity when there is a full extent of in-flow wedge. From measurements of film thickness by air gages, he finds a relatively close agreement between experiment and theory for a wide range of relative velocities of the rotating cylinders so long as there is a sufficient in-flow wedge. With a starved wedge, however, it is found that load capacity falls steeply on either side of the pure rolling condition, which explains the form of the curves obtained earlier by El-Sisi and Shawki [357].

Journal-Bearing Mathematics. Mathematical techniques for the solution of film forces in finite journal bearings with fully continuous films at constant viscosity were presented in a number of papers. Hays [358] contributes the use of a theorem by Helmholtz and Kortweg which states that the true motion of the fluid is one for which the difference between the dissipation within a region of the film and two times the work done by the surface forces is a minimum. By employing the variational calculus to meet the conditions of the theorem, he determines a solution in series form and shows that it is also a solution of the Reynolds equation. In this and another paper [359], Hays presents data, curves, and examples for the designer.

Fedor [360] makes available another interesting exact mathematical technique utilizing the Fourier series and presents the solution in one of the simplest algebraic forms available for determining the load capacity of the finite journal bearing with a circumferential feed pressure at one end. Although the film is fully continuous, a sufficient feed pressure may produce positive pressure throughout the film.

Tao [361] presents still another tool for the exact solution of Reynolds equation for the finite bearing with full film. By separating variables and by additional transformations, he arrives at Heun's equation, a comparatively little-known equation, from which pressure distribution, load capacity, and friction functions may be determined. In another paper [362] the same mathematical technique is applied to effect a solution for the finite film but with variable fluid viscosity.

Dynamics Loads, Whirl. Several papers appeared dealing with problems of the dynamic loading of bearing films. Two papers on journal-bearing instability offer theories to explain the many contradictory phenomena observed about whirl behavior. Sternlicht, Poritsky, and Arwas [363] present their mathematical approach for determining the transient and steady-state motions of the journal of a finite bearing with both incompressible and compressible fluids. Extending the previous work of Sternlicht [364], exact film-force functions are incor-

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porated including the velocities of the journal center. Some finished data are given on predicting the threshold of instability for an externally pressurized journal bearing under a nonrotating state. Another paper by Hori [365] offers experimental data and plausible qualitative explanations for the different types of instability based on the mathematical analysis of a journal bearing with a π film and without end leakage.

Jennings [366] has successfully obtained mathematical transient and steady-state whirl paths of a journal by solving the equations of motion on an electronic analog computer. Film forces are based on the short bearing approximation with π film, and the effect of journal-center velocity is included. Journal mass is shown to be an important factor in the size of the whirl orbit. By experimentation, Hull [367] shows that oil-whip frequency and amplitude may be effectively controlled by controlling the speed of a sleeve between journal and bearing. Rotating the intermediate sleeve opposite to journal rotation reduces whirl frequency to very much less than one-half and also markedly reduces the amplitude of whirl. Brix [368] shows results of whirl measurement in gas bearings, where whirl is due to rotor unbalance and occurs at rotor speed. He compares data with simple-vibration theory where the gas film is the spring.

Nahavandi and Osterle [369] show by an exact mathematical treatment the interesting result that the plane thrust bearing, often regarded as having no load capacity, may indeed have a high capacity equal to the tilting-pad thrust bearing, if the surfaces vibrate due to a built-in wobble or due to axial bounce.

Sliders With Liquid and Gas Films. Through the use of newer mathematical techniques and the digital computer, the volume of useful data on the finite slider with incompressible or compressible fluids has been greatly increased. Although the case of the finite slider with constant-viscosity liquid film has been previously solved, two recent papers offer different mathematical techniques for the solution of the Reynolds equation and contribute an additional range of needed data. Hays [370] utilizes the method of separation of variables and the use of Bessel functions to obtain a convergent-series solution, and Jakobsson and Floberg [371] use a numerical method to obtain a solution satisfying the Reynolds equation. Both solutions are in close agreement according to Floberg [372] who takes the next step, using his slider data to determine design data for tilting-pad thrust bearings and a procedure of design for minimum power loss and optimum number of pads.

A thorough study of the finite slider with gaseous lubricant is reported by a team of investigators in three papers: (*a*) By Gross [373] who carefully reviews lubrication theory and presents the mathematical solution for compressible slider films in both isothermal and adiabatic flow and with flat and crowned slider surfaces; (*b*) by Michael [374] who presents the numerical solutions by digital computation; and (*c*) by Brunner, Harker, Haughton, and Osterlund [375] who show experimental data for carefully finished flat and crowned sliders. The agreement of mathematical data with experimental is excellent, but better agreement is shown for the isothermal case. An interesting result is the confirmation of theory showing that a flat slider may choose between two film thicknesses one of which is unstable, whereas sufficient crowning of the surface makes the slider stable. Brody [376] extends the work of Gross and Michael and presents additional computer data for the finite flat slider with isothermal gas flow.

The infinitely wide parallel-stepped slider with gaseous fluid is explored by Kochi [377] who presents a rigorous mathematical solution including isothermal compressibility of the gas. He employs a graphical method to solve equations for pressure distribution and load capacity and presents examples and curves for design. Interesting comparisons are made of the bearing characteristics with cases where the fluid is either fully incompressible or fully compressible.

Hydrostatic Bearings (Liquid and Gas). Equations and data highly useful to the designers of hydrostatic thrust bearings are given in a number of papers for a variety of bearing configurations with different types of flow restriction. Among the many interesting mathematical solutions of fluid-film problems is that of conformal mapping which Raynor and Charnes [378] use in connection with flat hydrostatic thrust pads. They present the key mapping functions for the determination of pressure distribution, load capacity, and oil flow of incompressible films in bearings of circular, square, elliptical, and strip shape—all with a central feed source. Elwell and Sternlicht [379] give useful mathematics and data for the design of two types of circular hydrostatic bearings—the plain step bearing, and the annular pocket bearing. What is more important, they show the differences in the load capacity, fluid flow, and film stiffness of these bearings as influenced by three different flow restrictions, namely, capillary, orifice, and constant flow. Extensive experimental data are presented and excellent agreement is shown for the mathematical data. A similar paper by Sasaki, Mori, and Hirai [380] deals principally with the mathematics of hydrostatic bearings having capillary and orifice restrictions. However, the bearing configurations considered are not only for the circular plain bearing but for the spherical and conical bearings as well, all of which are shown to be of the same family of types. The circular hydrostatic bearing with a gaseous fluid is treated by Laub [381] who presents a rigorous mathematical solution for load capacity and flow, accounting for the compressibility of the fluid under isothermal expansion with an orifice restriction in the system. Experimental data for a range of step ratios and plenum feed pressures are presented and show excellent agreement for the mathematical solution. In a paper for designers, McNeilly [382] reviews the behavior and equations of the hydrostatic air-thrust bearing with restriction formed by the annular orifice of the film gap. Using this basic model, he derives the performance to be expected from a thrust plate between two opposed but fixed pads, and extends this second model to predict the performance of a journal bearing with a series of pairs of circumferentially placed pads.

Non-Newtonian Films. Several papers dealt with the complicated problem of predicting the load capacity and friction of bearings with non-Newtonian fluids. Horowitz and Steidler [383] present mathematical data on journal bearings without end leakage to compare load capacity and friction of shear-sensitive polymer oils with those of normal mineral oils having the same viscosity

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at low shear rate. Under constant-temperature conditions, both capacity and friction are lower for polymer oils. However, with temperature rise taken into account, polymer oils may exhibit load capacity and friction as high as certain normal oils because their viscosity index has been improved by the polymer. They do not find, as several experimenters have found, that the load capacity may be greater with the advantage of lower friction. DuBois, Ocvirk, and Wehe [384] present their work on finite journal bearings and their difficulties in attempting to show a correlation of mathematical analysis with experimental data which show that a polymer oil has superior load capacity to a normal oil when the friction of the two oils is the same. Burton [385] presents an interesting mathematical paper treating the complicated fluid as a Maxwell fluid taking shear elasticity into account as well as viscous flow. Inclusion of shear elasticity in the equations yields a relaxation number which is shown to have a first-order influence in reducing the load capacity and friction of a pair of rolling disks in contact without end leakage. Sasaki, Mori, and Okino [386] also deal with the no-side-leakage rolling-contact case, but the fluid is grease and their mathematical solution is based on the Bingham plastic model which includes the shear yield strength of the fluid. Core zones of equal velocity in the film profile are shown, and equations show that as the velocity of the surfaces is increased the influence of the shear yield strength decreases to a point where the behavior is Newtonian.

Turbulent Films. Complications about viscous shear are also manifest in dealing mathematically with turbulent flow in bearing films. Two mathematical papers appeared on the prediction of load capacity and power loss of infinite sliders with turbulent liquid films. Chou and Saibel [387] derive a nonlinear, partial differential equation for turbulent lubrication utilizing Prandtl's mixing-length theory and achieve a simpler equation by dropping negligible terms. Subsequent integrations for velocity and pressure distribution as well as for load capacity and power loss yield closed-form equations based on two terms of a power series. The authors show that both load capacity and power loss of the slider are increased by turbulent flow over laminar flow, depending on the value of an undetermined experimental constant. Tao [388] also presents a differential equation for turbulent lubrication but based on Blasius' power law of friction with two constants to be determined experimentally, the constants being well known for laminar flow. Integrations yield closed-form expressions for load capacity and power loss in terms of Reynolds number as a direct parameter. A numerical example is shown where, on the basis of a given maximum film pressure, the pressure distribution of a turbulent film gives a somewhat greater load capacity than a laminar film.

Misaligned Gas Bearings. Ausman [389] deals with the mathematical relationships of a compressible film in a journal bearing when the journal axis is misaligned at an angle about the bearing center. By assuming a power series for the pressure distribution to satisfy Reynolds equation, he achieves a solution from a first-order perturbation giving both the pressure distribution and the resultant torque. Characteristic curves are shown and are held to show reasonable first-order magnitude of torque when the angular misalignment is small.

Oil-Ring Bearings. From bearing experiments with many sizes of oil rings, Lemmon and Booser [390] present useful empirical formulas for the quantity of oil delivered by the ring to the bearing. Moreover, formulas are given for predicting ring speed when: (*a*) There is no slip between ring and journal, (*b*) slip begins, and (*c*) the ring is slipping due to a hydrodynamic film separating it from the journal. Rubbing of the ring at the ring-slot sides is shown to have a serious effect on the quantity of oil delivered, while depth of immersion in the oil bath is a minor variable.

Electricity in Bearings. Kaufman and Boyd [391] show interesting experimental data of the effect of oil-film thickness on the pitting of bearing surfaces due to electrical current. Pitting is shown to be negligible when the film is very thick and also when good metal contact is achieved at zero film thickness. However, at some intermediate film thickness, pitting is at a maximum and occurs at a rate depending upon voltage applied and electrical-circuit resistance. In another paper Boyd and Kaufman [392] show photographs of pitting damage and discuss how damage occurs, how it may be detected and reduced. Saloman [393] presents a survey of electrical bearing damage and the possible theories to explain damage of the metal and fluid. He proposes that shock waves may be the primary cause and that the film may change from an insulator to a conductor as it becomes thinner.

Bearing Design. Certain papers were liaison vehicles between research and design for the benefit of the everyday designer of bearings. In a series of several papers, Rippel [394] offers a modern manual for the detailed design of sleeve bearings with full hydrodynamic film, with marginal films, and with boundary lubrication. He presents an interesting design chart showing conditions where a bearing may be too short, too long, too heavily loaded, or inclined to be unstable. DeHart [395] broadly covers the entire field of bearings by listing all of the types of fluid-film and rolling-element bearings and rating them according to the type of service to which they are subjected.

Gas-Bearing Symposium. Excellent papers from many countries were presented at the International Symposium on Gas Lubricated Bearings held at Washington, D. C., in October, 1959. Many were reviews and surveys of research in specific countries while others were new mathematical or experimental-research offerings. Papers were offered by S. Whitley [396] and H. Sixsmith [397] of England; M. Graneek and J. Kerr [398] of Scotland; N. Tipei and V. N. Constantinescu [399] of Roumania; R. Comolet [400] of France; G. Heinrich [401] of Austria; T. Sasaki and H. Mori [402] of Japan; A. Slibar [403] and H. Drescher [404] of West Germany; and M. Reiner [405] of Israel. Papers from the United States were by D. D. Fuller [406]; H. G. Elrod and A. Burgdorfer [407]; B. Sternlicht, H. Poritsky, and E. Arwas [408]; J. S. Ausman [409]; W. A. Gross [410]; H. C. Rothe [411]; Z. N. Nemeth and W. J. Anderson [412]; G. K. Fischer, J. L. Cherubim, and O. Decker [413]; J. H. Laub [414]; and G. R. Fox and H. J. Sneck [415]. The very large task of editing and publishing the Proceedings of the Symposium was undertaken by The Franklin Institute who also conducted the meetings, and by the Office of Naval Research who sponsored them.

A Digest of the Literature for 1959-1960

Lubricant Properties

By Albert A. Schwartz[10]

Additives. A study of the effectiveness of oxidation inhibitors in insulating and lubricating oils was made by Brook [416]. The mechanism of inhibited oxidation was demonstrated by correlating the reactivity of oils toward tert-butoxy free radicals with the reciprocal of the induction period observed when these oils, inhibited with phenolic-type inhibitors, were oxidized in laboratory oxidation tests.

Prizer [417] investigated the application of methacrylate polymers as VI improvers, pour-point depressants, and low-temperature sludge dispersants in the formulation of lubricants for use over the entire range of temperatures encountered in operation of military aircraft.

Some of the effects of extreme-pressure or boundary-lubricant additives on metal surfaces were studied by Bennett [418]. Major emphasis was placed on investigating the mechanism of the action of zinc dithiophosphate additives because of their widespread use in automotive-crankcase lubricants. Hugel [419] studied the chemical nature of extreme-pressure lubrication with several organometallic complexes, which were found to produce beneficial solid films on rubbing surfaces at high temperatures and pressures. Increasing the detergency of the base oil was found to result in improved performance of the extreme-pressure additive.

A new testing apparatus was described by Oakes [420] and used to evaluate sulfurized oils, chlorine compounds, and chlorosulfurized additives. Polysulfides were found to be more effective EP agents than disulfides. The load-carrying capacity of both chlorinated and sulfurized oils appeared to be affected by the olefin type.

Murray [421] investigated the effect of extreme-pressure gear-lubricant additives on elastomeric vulcanizates used for the fabrication of oil seals. Possible chemical reactions between additives and elastomers; the effect of temperature, additive concentration, and sludge; and methods of inhibiting elastomer deterioration were studied.

The mechanisms of formation and removal of extreme-pressure films were investigated by Loeser, Wyquist, and Twiss [422] under both static and dynamic conditions, using radioactive phosphorus incorporated in the zinc dialkyl dithiophosphate additive as a tracer. The amount of film increased with increasing oil temperature. Dynamic tests also resulted in increased film thickness, indicating the marked effect of surface temperature and pressure.

Analysis, Testing, and Evaluation. Many new or revised standards for the testing of petroleum products and lubricants were issued by ASTM [423]. A number of the more widely used lubricant tests were reviewed and their significance discussed [424].

A method for the analysis of fatty-acid esters by gas chromatography was reported by Brenner, Scholly, and O'Brien [425]. The method makes possible rapid and accurate analysis of complex mixtures and should prove a valuable tool in the analysis of lubricating oils and greases.

Gibb and Gibson [426] developed an improved titrimetric method for the determination of the acidity of dark lubricating oils. The procedure is based on the use of a special fluorescent indicator.

An electrochemical method for the investigation of the micelle structure of detergent lubricating oils was reported by Bernelin [427], who used the method to demonstrate the existence of ionic colloids in hydrocarbon solutions of detergents.

Kikuchi [428] reviewed the subject of sulfur compounds in lubricating oils. Among the topics discussed were the types of sulfur compounds occurring in crude oils; separation and analysis of sulfur compounds in petroleum; desulfurization of lubricating oils; oxidation inhibiting, corrosion preventing, and extreme-pressure properties of sulfur compounds; and effects of sulfur compounds in lubricating oils.

The subject of deposits from lubricating oils during usage was reviewed [429]. The determination of the nature and source of deposit components and the conditions which cause them were summarized, and specific cases were presented to show how suitable analysis of deposits indicated their causes and pointed to solutions to a variety of deposit problems.

Ronan and McLaren [430] discussed the use of a number of modern analytical devices and described their application in the solution of practical problems in grease lubrication. A rapid method for the analysis and evaluation of lubricating greases was presented by Chamberlin, Carter, and Dreher [431].

Pavelescu and Iliuc [432] utilized radioactive tracers and a Geiger-Müller counter to investigate the effect of viscosity on lubricant-film thickness. Two methods for measuring film thickness are described.

A critical review of the widely used cloud and pour-point methods as means of assessing low-temperature-use limits of lubricants was presented by Hutton [433]. The shortcomings of these methods are discussed and evidence presented that they should not be used as criteria of flow properties. Some of the mechanisms by which additives increase fluidity are also discussed.

A study of the kinetics of vaporization of petroleum lubricating oils was reported by Volynets [434]. Evaporation rates were determined by measurement of weight loss of thin layers of oil on strips of paper.

Barger, et al. [435] described a rapid method for measuring the heat capacities of lubricating oils over extended temperature ranges. The design and operation of a simplified semiadiabatic calorimeter and a method of calculation are outlined which permit determination of heat capacities with less than 5 per cent error.

An improved rotary bomb oxidation test is reported by von Fuchs [436]. The test permits rapid evaluation of the resistance of all types of lubricants to oxidation and sludge formation under dynamic equilibrium conditions. The test can be used to determine oxidation and hydrolytic stability, inhibitor susceptibility and corrosivity

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to metals, as well as mutual compatibility of new and used oils and oil service-life expectancy.

A research study of the basic rate-controlling mechanism in laboratory-scale investigations of lubricating-oil oxidation was reported by Tse [437]. The difficulties encountered and factors to be considered in making this chemical-reaction kinetics study were discussed.

Pohorilla and Hart [438] describe equipment and a procedure for a simple laboratory oxidation test for gear lubricants under conditions simulating operating environments. Test data indicate correlation with field experience with inhibited straight-mineral-oil systems. A program for the development of reliable test techniques for the evaluation of the thermal-oxidation stability of gear lubricants was reported by Meckel and Quillian [439]. Investigation of thermal-oxidative degradation phenomena was facilitated by isolation of oxidative and temperature effects.

Yanis and Wolfe [440] described a program for the evaluation of cutting fluids. Preliminary screening tests were used to select the most promising materials for further evaluation in machinability tests. The results showed good correlation with field experience.

A simplified laboratory method, utilizing the combined data from Falex, Timken, and 4-ball test machines for the evaluation of the load-carrying capacities of gear oils, was reported by De Ardo and Sargent [441]. The method was applied to typical commercial heavy-duty gear oils and was found capable of classifying them.

Hirano and Yamamoto [442] used the 4-ball tester to investigate the effect of solid particles on the performance of lubricating oils. The effects of hardness, particle concentration, and oil viscosity were studied. Abrasive wear increased with increasing particle hardness.

A reproducible rust test for greases, capable of providing a quantitative distinction among greases with varying rust-preventative capacities, is reported by Fisch, Messina, and Gisser [443].

Greases. Criddle and Dreher [444] investigated the yield points of lubricating greases. Using a specially developed stress-strain apparatus, the yield points were found to be dependent on three variables—rate of deformation, type of deformation (compressive or shear), and the work history of the grease. Stress-strain curves for lubricating greases were found to be similar in character to those obtained for metals.

The Bingham body concept and the theory of rate processes were used by Sisko [445] to develop a general equation for the flow of non-Newtonian fluids. The equation was found to describe accurately the flow of the greases studied over a shear-rate range from 0.04 to 22,000 sec^{-1}.

Yamaguchi and Oki [446] carried out plastometric measurements of the flow properties of greases. The existence of creep phenomena was noted in each grease tested. It was experimentally shown that syneresis in grease proceeds in direct proportion to creep, and that the firmness of grease can be approximately expressed by Nutting's formula for the firmness of viscoelastic bodies.

An equation for expressing the flow of lubricating greases over the shear-rate range from 10^{-3} to 10^{4} sec^{-1} was developed by Sisko, Brunstrum, and Leet [447], who applied it successfully to data from capillary viscometers, a cone and plate viscometer, and pipes. Calculated velocity profiles corresponded closely to experimentally measured results.

Bauer, et al. [448] studied the effects of temperature on the flow properties of greases in capillary and in cone-and-plate viscometers. Results indicated that various structural elements in greases have different temperature coefficients of resistance to flow and behave differently in the two types of viscometers.

A method of using capillary viscometry data for predicting grease flow in centralized grease-dispensing equipment was reported by Savins [449]. The method differs from earlier similar methods in that it provides a correction for the "end effects" characteristic of efflux-type viscometers, thus permitting more accurate correlation with grease flow in pipes.

Borg and Leet [450] studied the effect of thickener particle dimensions on grease properties. The effects of the length-to-width ratio of thickener on mechanical stability, age hardening, and grease leakage of lithium-hydroxystearate mineral-oil greases were investigated. Increasing length-to-width ratio was found to result in increased mechanical stability, increased grease leakage, and decreased age-hardening.

Statistical methods were applied by Clifee and Pearson [451] to grease-penetration test data to determine the most suitable methods for control of the consistency of semifluid greases. Various rheometric methods were compared and their ranges of application determined.

Radiation Studies. The effects of gamma radiation on aircraft-instrument lubricating oils were investigated by Rice [452]. Changes in the physical and chemical properties were shown as a function of increasing gamma exposure. Empirical equations were derived relating some of the observed property changes to the size of the radiation dose.

Neely [453] compared the effects of irradiation on aircraft lubricants under static and dynamic conditions. The results indicated the need for dynamic tests in reactor radiation environments because of accelerated breakdown under these conditions. It was found that service life could not be predicted on the basis of static irradiation.

A review of the problems in lubrication presented by nuclear power plants was presented by Williams [454]. The radiation stabilities of petroleum oils and commercially available silicone lubricants were compared.

Fischer, Zack, and Warrick [455] studied the effect of radiation on the stability of several silicone greases. Considerable variation in radiation stability was noted, with stability increasing with increasing aromatic content of silicone fluid. Radiation stability was found to be a function also of thickener composition.

Rice and Kirk [456] reported on recent progress in the development of radiation-resistant fluids and lubricants. Data were presented on the effects of gamma radiation on various materials, showing their limitations. The polyphenyl ethers were found to be outstanding in their stability toward thermal and nuclear radiation.

Rheology. A nomograph for determining the viscosity of oil blends to within 2 per cent was developed [457].

A study of the flow mechanism of thixotropic substances was carried out by Hahn, Ree, and Eyring [458]. A theory to explain thixotropy quantitatively is presented, and, based on this, a system of flow equations is derived. The theory is applied to various substances.

Klaus, Jolie, and Fenske [459] investigated the effect of polymer structure on the viscosity properties of polymer solutions. The viscosity effects of linear polymers on their solutions were measured and compared for 12 polymers representing eight molecular structures.

O'Donnell [460] reviewed the subject of viscoelasticity in lubrication, discussing how viscoelastic effects occur in such mechanisms as high-speed bearings and gears, and under what conditions various fluids display viscoelasticity.

Miscellaneous. The role of solid additives in fluid lubricants was investigated by Herzig [461]. Using an empirical formulation, effects of particle dimensions and concentration are quantitatively described with good agreement with experimental results.

Vineall and Taylor [462] carried out an experimental investigation of the behavior of molybdenum disulfide as a lubricant. Lubricant properties both alone and in the presence of petroleum oils were evaluated.

An apparatus for the investigation of lubrication and the evaluation of lubricants at extremely high temperatures was described by Bartel [463]. The apparatus was used to study glass and water-soluble-eutectoid salt mixtures as lubricants at temperatures to 1000 C.

Saloman [464] studied the effect of electrostatic charges on machinery and lubricating oils. The effect on the formation of oil films and in pitting wear was investigated with a new explanation of the mechanism of wear.

Dixon and Clark [465] synthesized four polyalkylbenzenes and polyalkylcyclohexanes of the types suspected of being prominent in the lubricating-oil fraction of petroleum, and determined their physical properties.

New fluoroester lubricants for high-temperature applications were discussed by Ballard and Sommers [466]. Physical and chemical properties and laboratory performance-test results were reported for fluoroalkyl camphorate and pyromellitate.

Groszek and Bell [467] devised a method for using an electric-discharge detector to measure the vapor pressures of the liquid phase in soap-hydrocarbon systems. The results were used to construct desorption isotherms for the systems which in turn provided information concerning the surface area of the solid phase and the proportion of liquid present in pores small enough to depress the liquid vapor pressure.

A systemization of the most probable states for solids-dispersed inorganic media was developed by Chessick [468]. Flocculation is explained on the basis of (primary) van der Waals attractive forces and secondary and tertiary attractive forces. Deflocculation is explained as due to steric hindrance, absorbed lyosphere, entropic repulsion, or double layer effects.

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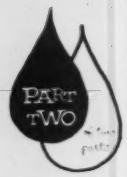

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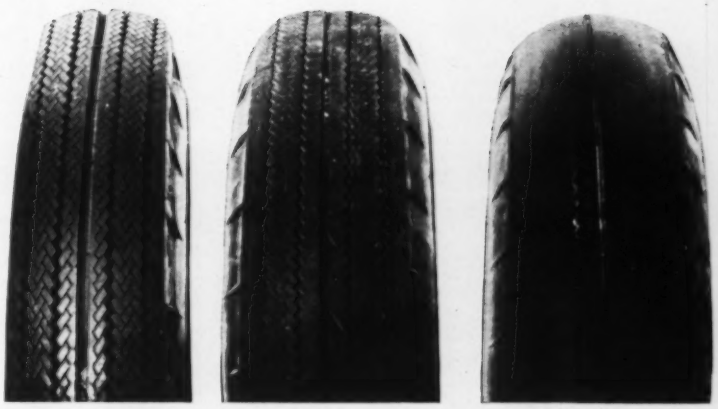
Abstracts and Comments Based on Current Periodicals and Events

D. FREIDAY
Associate Editor

BRIEFING THE RECORD



Left to right, new tire, condition after 9000 miles, and after 15,000 miles. Both nylon and Tyrex tire cords retained very high percentages of their original conditions under the same severe test conditions.

Tire-Cord Failure

TIRE CORDS—both nylon and Tyrex viscose—maintain a high percentage of their original strength for up to 100,000 miles of service.

Cord fatigue, defined as "a gradual and continuous weakening of the cord to a point where it becomes so weak that it ruptures," is not a factor in tire failure.

The probable cause of cord failure is adhesion breakdown, and mileage is not a reliable indicator of impending failure. Furthermore, the results hold true regardless of the severity of tire-service conditions.

These are the principal conclusions of a two-year tire-research program conducted by Fabric Research Laboratories, Inc., an independent research company located in Dedham, Mass., and reported at the annual meeting of the Textile Research Institute.

Tire cords studied were removed from: (*a*) Standard model 7.50 × 14 tubeless nylon and Tyrex tires driven up to 100,000 miles (recapped every 20,000 miles) at normal inflations and normal weight loads on New York taxis; and (*b*) standard model 6.70 × 15 tubeless tires driven up to 15,000 miles in Nevada at an average speed of 70 mph at extremely low inflation (18 psi where 28 psi was the manufacturer's recommendation) and heavily weighted (1172 lb per tire).

A severe Nevada test was conducted at the urging of tire and cord manufacturers who sought to find out if the results of an earlier New York taxi-fleet test—in which both nylon and Tyrex cords were found to retain most of their original strength after 100,000 miles of city driving—would be confirmed in tires driven at turnpike speeds under extremely unfavorable conditions of inflation and weight load.

In the Nevada test, three types of tires were used: Tyrex 1650/2, nylon 840/2, and a German viscose 1650/2. The latter was chosen because it uses an isocyanate cord adhesive claimed to have distinct advantages in terms of adhesion and fatigue life.

The Nevada road test was carefully controlled and certain tires were removed for laboratory dissection and study after 1000, 3000, 9000, and 15,000 miles.

During the entire 15,000 miles no tire failed due to cord failure. Rubber tread was adequate after 9000 miles but tires were essentially bald after 15,000 miles. Nylon retained 85 per cent of its original strength, Tyrex 82 per cent, and the German viscose 74 per cent after 15,000 miles of road wear. Most of the small strength losses that did occur happened in the first 3000 miles and there was very little loss of strength after that. None of the cords had anything close to a dangerous strength loss.

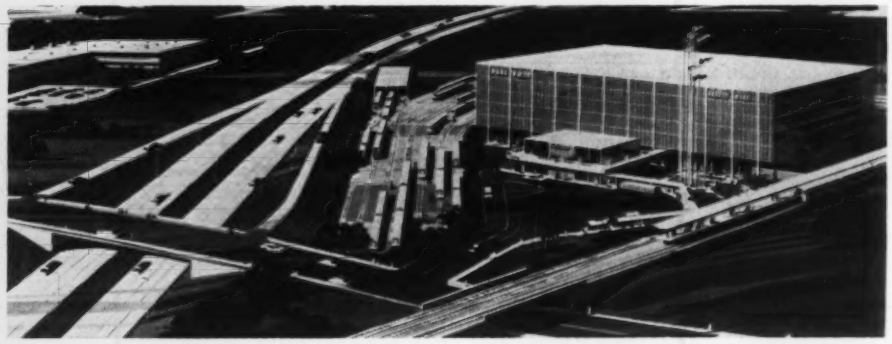
Cord strengths corresponded to those found in the New York taxi tires except that under the more severe service conditions of the Nevada test the major portion of strength loss occurred in 3000 miles as opposed to 15,000 miles in the New York test.

Because there were no cord failures it was not possible to determine any advantage for the isocyanate adhesive, although it was discovered after tire dissection that cords so treated were more uniformly coated with rubber than were the nylon and Tyrex. This might have significance at increased mileages.

The upper sidewall region was found the weakest in the Nevada test, whereas the lower sidewall, or flex, region was the weakest in the New York test—a difference which was almost certainly explained by inflation levels and speed.

It was concluded, after rather thorough tests of tires run under normal and severe conditions, "that currently popular tire cords—both nylon and Tyrex—maintain their strength integrity almost indefinitely in well-designed quality tires and the idea that they gradually weaken to a point where failure is inevitable should not be given credence. In short, nylon and Tyrex are both very adequate materials for tire cord—perhaps better than had been generally realized."

Chicago has attempted to solve the commuter problem by combining rapid-transit facilities with an express highway and adequate suburban parking. The highway is already approaching its capacity, but the rapid-transit facility is operating at less than 30 per cent of capacity and is already carrying 1.3 times as many persons during rush hours as the highway, although it cost less than $4 million per mile compared with $10 million per mile for the highway.



Rapid-Transit Superhighway Combination

CHICAGO's rapid-transit route located in the middle of the depressed Congress Expressway has completed its first year and a half of operation. The expressway already operates at capacity but the mass-transit facility can be more than tripled in capacity with longer and more-frequent trains.

According to an article by V. E. Gunlock, chairman of the Chicago Transit Authority, in the March, 1961, *Civil Engineering*, the highway, costing approximately $10 million per mile, with four lanes in each direction, is carrying roughly 7500 persons inbound during the morning peak hour and the same number outbound at night.

The rapid-transit line, costing less than $4 million per mile, carries about 10,000 passengers per hour in the heaviest direction during the morning and evening peak. Thus the rapid-transit facility operating at less than 30 per cent of capacity is already carrying over 1.3 times as many persons in the heaviest hours as the expressway which is operating at or near its design capacity.

The importance of rapid transit during the hours of heaviest travel is emphasized more dramatically by an analysis of a count of passengers entering and leaving the Chicago central business district, made in May, 1960. These data show that, in a peak 15-minute period, the rapid-transit line carries over twice as many passengers in the rush direction as the expressway—about 3100 by rapid transit compared to 1400 by automobile.

At least $11^1/_2$ per cent of the patrons formerly commuted by auto. To attract as many auto passengers as possible to the rapid-transit line, both "park-n-ride" and "kiss-n-ride" facilities are planned for the Forest Park terminal facilities. A 2000-car garage will be expandable to 6000-car capacity and there will be ample short-time parking space for motorists who pick up and deliver "kiss-n-ride" patrons. A shopping center may also be added.

The project was a joint venture of the city of Chicago, Cook County, the State of Illinois, the Federal Bureau of Public Roads, and the Chicago Transit Authority. Chicago plans more integrated facilities of this type when funds are available.

Ultrasonic Welding for Plastics

TOUGH oriented polyester plastic films can be joined with Sonoseal, an ultrasonic welder developed by Ultrasonics, Inc., Cranford, N. J. The heatless sealing method can be used for audio or video tapes, machinery belts, packing materials, plastic raincoats, or even metallized plastics of the type used in the Echo satellite. There is no disorientation of the chains of molecules as in heat sealing.

Oriented plastics get their unusual properties of strength from their manufacturing process in which the chains of molecules are oriented in lines which strongly oppose breaking or tearing. Sonoseal imparts its ultrasonic vibrations to overlapped sections of the materials to be joined, causing plastic flow and a bonding of the molecules of the interface layers of the materials. With the development of Mylar and Cronar and the other exceedingly strong oriented plastics, the problem of joining them either to each other or to dissimilar materials became a serious one.

Powered by a 100-watt generator, the new device has a built-in automatic frequency-control device which adjusts to the thickness of the material and applies the

power required to effect a perfect seal, thus eliminating the possibility of operator error. In the event that the frequency drifts off because of trouble in the tuning circuit, the machine automatically shuts itself off.

A patent has been applied for on the modifications the company has designed into the Western Electric patented ultrasonic horn which they have been licensed to fabricate. The transducer mounted in the horn is a standard lead-zirconate-titanate element.

Capable of providing seam widths from 0.030 to 0.1000 in. or wider, overlaps may be made from $^1/_{64}$ to $^1/_{1000}$ in. or down to the range of structural stability. Thickness range is up to 0.012 in., although it can be extended to 0.020 in. for some plastics. Actuated by a foot pedal that energizes the mechanical feed system which transfers the materials to be welded past the welding tip, much in the same manner as a sewing machine, the welding rate—depending upon the type and thickness of the plastic—may be as much as 600 ipm.

Heat is completely eliminated at the contact point by making the interchangeable welding tip serve as a heat sink. Aluminum has been used, although copper or any other high-thermal-conductivity material that would conduct heat away from the contact surface would serve equally well.

Ultrasonic power is supplied by a 100-watt generator built within the unit. It operates on 120-volt 350-watt 60-cps a-c power. In addition to the standard sewing-machinelike console, fully automated plastic Sonoseals can be furnished to meet particular service requirements.

Uniloy 303MA Stainless

Universal-Cyclops Steel Corporation, Bridgeville, Pa., announces the commercial availability of a new free-machining chromium-nickel stainless steel, designated Uniloy 303MA.

The greatly improved machinability of Uniloy 303MA, compared with regular free-machining AISI Type 303, permits increased output of machined parts and longer tool life, resulting in considerable dollar savings for plants now using regular Type 303 for machined parts.

Uniloy 303MA has other plus values in the characteristics of finished parts. Corrosion resistance is much greater than that of Type 303 and the surface finish is far superior.

It is estimated that the potential market for Uniloy 303MA is $25 million per year. Most of the demand for this new alloy, as with Type 303, will probably be in the form of cold-finished bar. The demand for cold-finished stainless bars has been growing at a more rapid rate than stainless steel as a whole during the past 15 years. This accelerated growth is expected to continue during the next five years.

The key to the difference between Uniloy 303MA and Type 303 is in the analysis. In Uniloy 303MA the proper combination of aluminum (0.70) and sulfur additions for better machinability makes possible a reduction in the sulfur content to about one half the level normally contained in Type 303 (from 0.25 to 0.13). Uniloy 303MA is covered by Patent No. 2,900,250.

The addition of significant quantities of sulfur to stainless steels for improved machinability actually results in undesirable side effects. The sulfur content takes the form of nonmetallic stringers and inclusions, which adversely affect the fabrication and performance of parts. The superior mechanical and corrosion-resisting properties of Uniloy 303MA are, to a great extent, the result of cleaner steel obtained by the use of much lower sulfur content than is necessary in Type 303.

The material has been thoroughly tested in production runs in over 100 customer plants for a wide variety of parts. These tests conclusively proved that Uniloy 303MA can be successfully machined up to 50 per cent faster than regular Type 303. Further dollar savings resulted from increased tool life and less down time for changing tools.

The nonmetallic inclusions in regular Type 303 have caused considerable problems in rolling operation in the way of longitudinal splitting which have been eliminated with Uniloy 303MA.

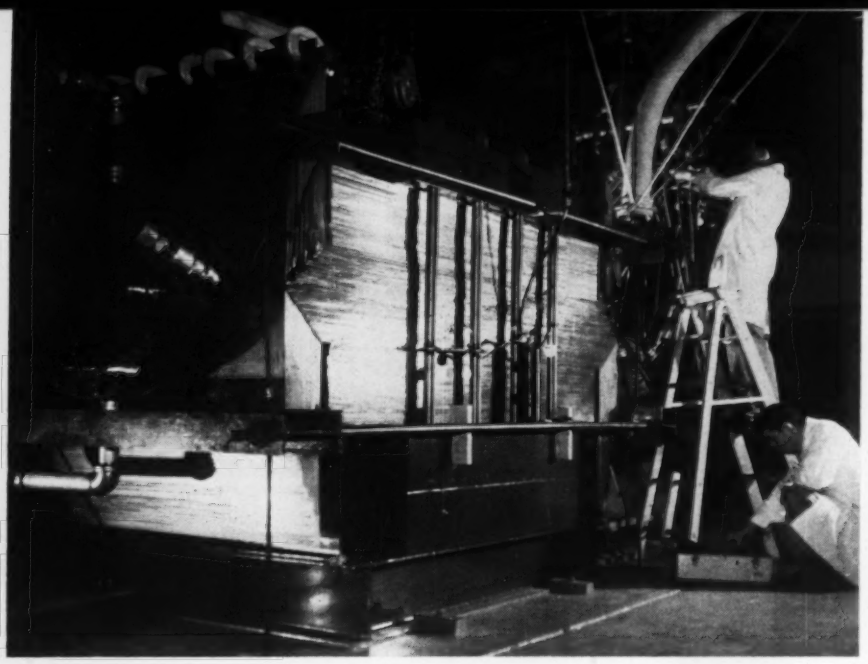
The harmful effects of inclusions in regular Type 303 prevent the forming of threads by rolling. Uniloy 303MA can be successfully roll threaded, with excellent surface finish and a great savings in threading costs.

The new material can be electropolished to a very high luster resembling the best results obtainable with low-sulfur stainless steels such as Types 302 and 304.

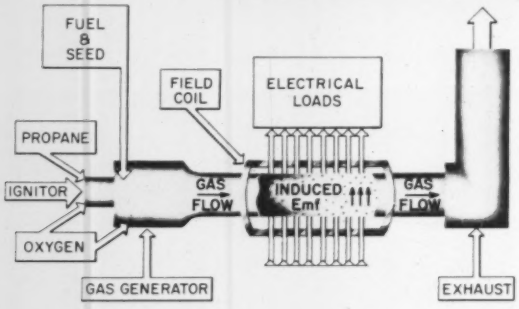
Corrosion resistance of Uniloy 303MA is 25 times greater than Type 303, and approaches that of Type 304, as proved by the widely recognized Huey Test.

Uniloy 303MA can be satisfactorily arc welded, flash welded, percussion stud welded, and brazed when proper techniques are used.

Spindle speed was increased 40 per cent and cycling time was reduced 25 per cent by using a new stainless steel—Uniloy 303MA—for the part shown in the insert. The proper combination of aluminum and sulfur is responsible.



The Mark II MHD power generator, **right,** is designed for ultimate production of over 500,000 watts of power. Flow chart, **below,** shows that the gas is heated to 5000 F in a rocket-engine-type gas generator. To increase its ionization, the gas is seeded with a potassium salt. The ionized gas flows down the channel and across the magnetic field, creating an electric voltage. Power is tapped off to the load by electrodes, while the gas passes through the exhaust to the atmosphere.



Progress on MHD

PROGRESS in the generation of power by magnetohydrodynamics, MHD, has been announced by the Avco Corporation and American Electric Power Service Corporation. Prospects for commercial power generation have advanced with the production of 205 kw in a new MHD generator at the Avco-Everett Research Laboratory, Everett, Mass. This is 20 times greater than the power output achieved when the project was first revealed late in 1959 (MECHANICAL ENGINEERING, January, 1960, p. 52).

The basic idea, first investigated by Michael Faraday some 150 years ago, is that the conductor which moves through the magnetic field need not be a wire—it could be a fluid. Now, with today's knowledge of high-temperature gas properties developed through the space exploration program (the re-entry problem gave the essential data), it is possible to generate power by sending a high-temperature, ionized gas through a magnetic field. This eliminates the turbine and the armature, which could improve the efficiency of power generation by as much as 40 per cent.

Philip Sporn, Hon. Mem. ASME, and president of American Electric Power, said: "Magnetohydrodynamics is probably the most exciting area of development in power generation today."

In the new Mark II generator now in operation at Everett, the plasma, or hot gas, is provided by a combustion chamber similar to a rocket thrust chamber, which burns a mixture of kerosene or alcohol and gaseous oxygen "seeded" with powdered potassium to make the plasma a better electrical conductor. The plasma enters the generator at about 5000 F.

The problem has been one of getting materials to withstand the high temperatures. By enriching the combustion air with oxygen, preheat requirements have been reduced to the point where a conventional material such as stainless steel can be used. This means that regenerators (preheaters) currently available commercially can be employed in the MHD system. Dr. Arthur Kantrowitz, vice-president and director of the laboratory, said: "Now that auxiliary components of the MHD power plant already exist, only the generator itself requires further development."

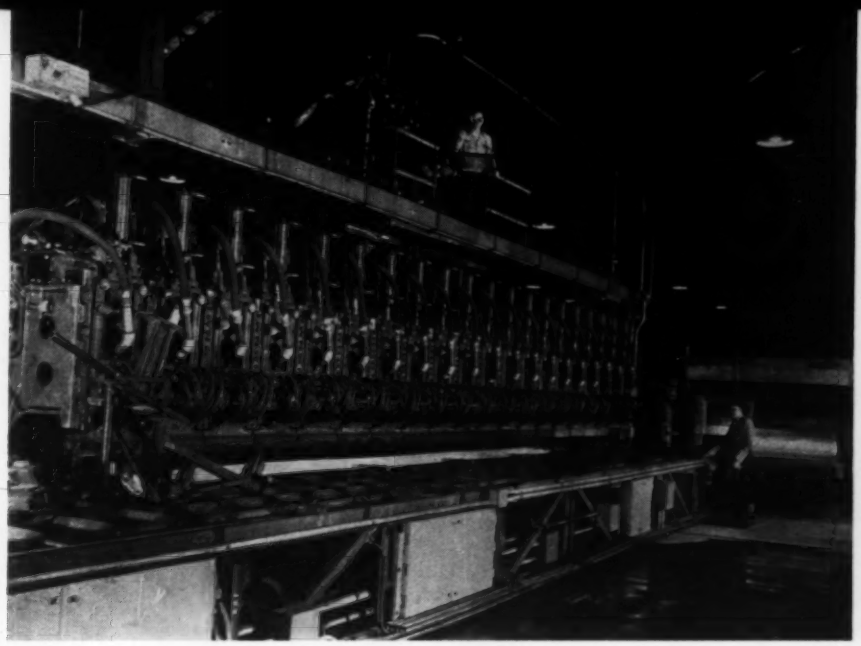
The Mark II generator is designed for runs of up to one minute, which is more than adequate for studies of fluid mechanics. It will provide answers to questions such as: What are the engineering problems connected with a large-scale MHD power plant? How does actual performance compare with theoretically predicted values? How do the materials used in the generator stand up to the high temperatures of the plasma?

The generator can get its hot gases from burning coal, oil, gas, or from a nuclear reactor. Current must be converted from the direct current of the generator to alternating current.

Dr. Kantrowitz said that within two or three years research will have progressed to the point where it will be possible to plan a working power plant. It is his belief that commercial power generation by MHD will be a reality before 1970.

Many engineers foresee this as a first stage in a power plant, the hot gases then going to a turbine. Thus MHD will "top" the power plant, its own high efficiency raising the over-all efficiency of the plant.

Two more utilities have been added to the original 10 participating in the development program. The new participants are: Boston Edison Company, Boston, Mass.; and The United Illuminating Company, New Haven, Conn.



Both quenching and straightening are accomplished in a single mechanical operation with a new machine. Side rails up to 40 ft in length made of intermediate manganese steel are taken from the furnace and rapidly transferred to the quench machine. There they rest on knock-out rods until these drop and lower the rail into the machine.

Die-Quench Machine

THE Automotive Products Division of the A. O. Smith Corporation, Milwaukee, Wis., has developed a new process and the accompanying machinery for die-quenching and straightening transportation-equipment side rails up to to 40 ft in length. Improved mechanical properties developed through the process permit the use of lighter side members without loss in vehicular strength. An extremely versatile material—intermediate manganese steel—has been used with an advanced quenching technique.

The company is confident that this combination provides the most economical and technically advanced process for the production of heat-treated, high-strength side members for the transportation and allied industries.

A company spokesman stated that the process "makes it possible for these industries to produce lighter and stronger equipment at a time when the ratios of weight to payload and weight to economy of operation are of extreme importance to the sale of such equipment."

Previously, a considerable percentage of the production cost of side rails resulted from hand-labor straightening operations to relieve distortions after heat-treating. These hand operations likewise were a limiting factor on the mass production of such supporting members.

The quenching and straightening are now accomplished in a single mechanical operation. The side rail is taken from the furnace with A. O. Smith-designed-and-developed materials-handling equipment. It then is rapidly transferred—a critical point in the process—to the quench machine where it rests on top of knock-out rods. The rods drop, lowering the rail.

A punch next enters the rail and expands as the outer wall of the die approaches and makes contact with the side rail. Increased pressure for straightening is then applied.

The following step in the operation is the circulation of quench water through the punch and die, flowing through wafflelike faces against all sides of the rail.

The outer die wall then moves back and the punch rises. The knockout rods lift the quenched and straightened rail out of the machine. Rear pushers slide it back on the transfer equipment which moves it away. Essentially, this completes the operation.

Usual side-member alloys cost as much as 69 per cent more than carbon steel, but only a 16 per cent rise was associated with the intermediate manganese alloy. Metallurgical research revealed that the manganese material, while a leaner alloy, possessed the potential to develop properties comparable to enriched steels, providing a more potent quench was applied. Compared with a richly alloyed and easily hardenable steel—SAE-8620—the intermediate manganese alloy shows comparable engineering properties and metallographic structures in as-quenched and tempered specimens.

6,000,000-Lb-per-Hr Boilers

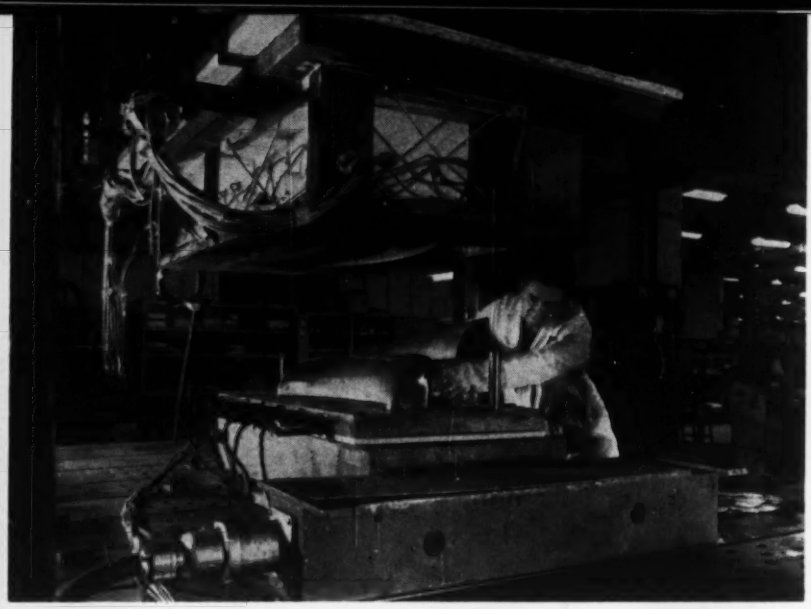
TENNESSEE VALLEY AUTHORITY has awarded a contract to Combustion Engineering, Inc., to supply two boilers—the largest ordered to date in this country or abroad. They will serve two 900-mw General Electric turbine-generators, the order for which was placed last December. Originally specified as 800-mw (MECHANICAL ENGINEERING, April, 1961, p. 73), their size has since been increased to 900-mw.

The contract price for the two boilers is $34,660,000, the second being covered by an option which may be exercised on or before July 1, 1962. The contract price for a single boiler is $17,440,000.

Statistics of the giant boilers are staggering. Each unit towers 18 stories high and has twin furnaces totaling 114 ft in width. The furnaces have a total volume equivalent to that of 74 ranch houses 30 × 20 × 10 ft high. The 8000 tons of tubing used in each boiler would stretch 265 miles.

One third larger than any other boiler ordered to date and designed to produce more than 6,000,000 lb per hr of steam at 2400 psi and 1050 F, each boiler will consume coal at a rate of 315 tons per hr.

The first unit is scheduled for operation by September, 1964, and the second a year later.



Electrically heated dies make possible simultaneous forming and stress-relieving of titanium at 1000 F. It is no longer necessary to form them mechanically and then prevent springback by wedging during heat-treatment.

Press With Electrically Heated Dies

A 1000-TON Erie press with electrically heated dies—permitting forming and stress-relieving in one operation—plays a significant part in speeding production of Crusader Navy jet-fighter planes at Chance Vought Corporation, Dallas, Texas.

The press is used primarily in the forming of titanium. Previously, titanium parts were partially formed mechanically, then wedged to prevent springback while undergoing heat-treating.

Application of the advanced technique brought with it certain problems. A major one was the heavier burden placed on operating parts of the press. To handle both forming and stress-relieving of titanium parts, high temperatures and pressures have to be maintained for longer periods. At the same time, the importance of the parts requires the press to be operated on a continual basis. Since parts are not stored, operation is essential to keep the assembly line functioning.

A full-time electrician maintains the electrical set-up which includes a total of 77 electrodes of 450, 500, and 1000 watts used in heating the ring and dies to the 1000-F forming temperature.

To provide adequate lubrication of hydraulic mechanisms and other working parts subjected to elevated temperatures and pressures, Gulf Harmony oil is used as the hydraulic medium. Relatively high flash and fire point are characteristic of this paraffin-base oil as contrasted with those of the naphthenic-base oils.

Oxidation resistance is indicated by its 1500-hr minimum life under the ASTM D 943 oxidation test. At the same time, the oil is effectively inhibited against corrosion to prevent rusting of press parts, and a powerful antifoam additive contributes to smooth functioning of the presses.

Other presses in the plant include a 19,500-ton HPM Diaform, a 5000-ton Erie, two Sheridan and two Erco stretch presses.

Chance Vought's success with electrically heated dies has interested other aircraft and missile companies working with the newer alloys. Some are experimenting with gas or electrically heated dies themselves. Others are subcontracting this difficult field of specialty forming to Chance Vought.

Ultrahigh-Temperature Furnace

FUSED stabilized-zirconia refractory, a valuable military and industrial research tool since its development by the Norton Company, Worcester, Mass., in 1951, has recently been placed in service in its first commercial application as a refractory for furnace construction.

A furnace designed to operate continuously at elevated temperatures in the vicinity of 2200 C (3992 F) has been built by C M Manufacturing and Machine Company, Bloomfield, N. J. The refractory for lining the hot-zone is fused stabilized zirconia manufactured by the Norton Company. The heating elements are specially selected and machined tungsten rods. The furnace can be operated with hydrogen or other reducing or inert atmospheres that are compatible with the furnace materials.

The pilot model of this furnace was built to provide a means of sintering large pressed tungsten ingots. Heating the metal for as little as 1 hr in the hot-zone of the furnace has increased the metal density sufficiently to permit hot working to reduce the diameter of the ingot.

This ultrahigh-temperature furnace has many potential uses in the study and production of special ceramics, cermets, and refractory metals. The hearth opening on the pilot model is 5 in. × 8 in. Building a furnace with a larger cross section appears to present no particular problems when considered from a design and engineering standpoint.

Continuously Operating Optical Maser

THE optical gas maser—an approach to light amplification entirely different from the solid-state masers recently announced by Hughes Aircraft Company and Bell Telephone Laboratories (MECHANICAL ENGINEERING, September, 1960, p. 75; and December, 1960, p. 72)—has been demonstrated by Bell Labs. It was the result of a "planned scientific discovery."

The new maser uses a mixture of helium and neon gas to achieve continuous operation and the power required is only in the tens-of-watts range. Previous optical masers—built around crystals—required thousands, even millions of watts of power to transmit large bursts of visible light of very short duration.

More than 225,000 net tons per month of high-quality sintered-ore charge are produced for the blast furnaces at Aliquippa, Pa. The hearth has an area of 2419 sq ft and a width of 13 ft 2 in.

Largest Sinter Line

A SINTER line capable of producing more than 225,000 net tons or 3000 railroad cars per month of high-quality feed for blast furnaces has gone into operation at the Aliquippa, Pa., works of Jones and Laughlin Steel Corporation.

Built by Dravo Corporation, Pittsburgh, Pa., under a licensing agreement with the Lurgi Company of West Germany, the plant is part of a three-year cost-reduction program which includes capital expenditures for ore beneficiation, open-hearth improvement, precipitators for smoke control, a new electrolytic line, and a continuous annealing line which is already in production.

The 10-story-high installation spreads over almost six acres and produces a charge for the iron-making blast furnaces rich enough to increase performance by as much as 20 per cent. There is less slag. Less coke and limestone are used. Higher hot-blast heat can be used and greater speed and better quality are possible in the actual process of reducing iron ore to molten iron.

Sintering is the process which makes it possible to utilize small particles of iron ore, or "fines" which otherwise might be lost in blast-furnace operations. Air is pulled through a loose bed made up of a dampened mixture of these small particles of iron ore and fuel, so that the fuel is burned and the ore particles fused together in much the same way as a housewife blends materials in cooking. Particles of coke, known as coke breeze, are intermixed to provide the fuel for fusing these small particles.

Sudden-Expansion Heater

A "SUDDEN-EXPANSION" burner system, capable of stable burning operations up to 5600 F and 1000 psi, is being produced by the Marquardt Corp., Van Nuys, Calif.

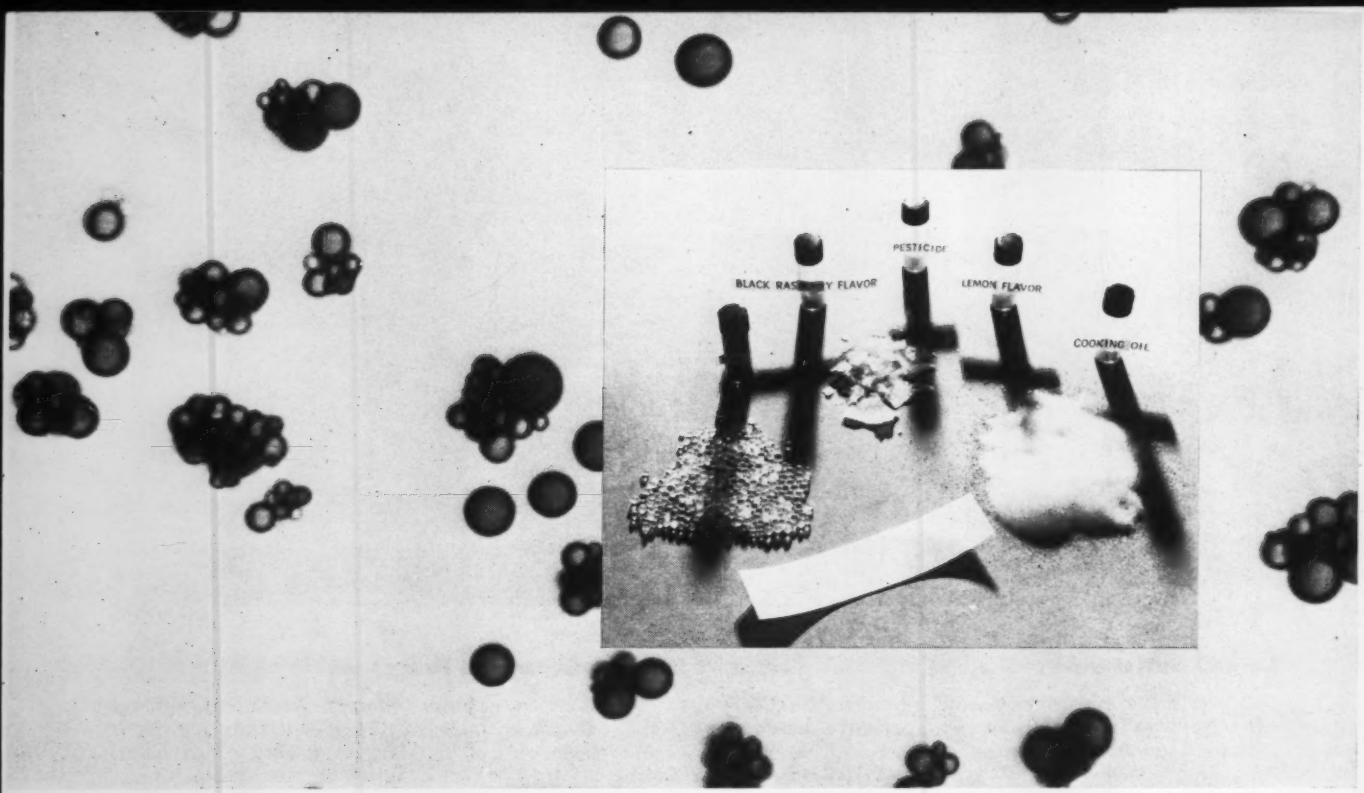
Based on the design of heater systems for simulating extreme ramjet and rocket operating environments, the Marquardt heater is applicable to a wide variety of industrial-heating and process systems, including high-temperature materials testing, intermittent steam generation, partial-oxidation reactors, liquid condensation, sound generation, and air heating.

Simple in construction and compact, the all-metal unit can be either air-cooled or water-cooled depending upon individual requirements. The heater utilizes a high-velocity combustion technique to obtain high thermal capacity in a small combustion unit. This permits the handling of heating loads with a relatively low-cost system.

Flexibility of the burner system allows operation over a wide range of conditions. Broad temperature-modulation capabilities will permit stable continuous operation over a range of 150 to 5600 F.

Specially constructed units of the Marquardt process heater are currently in operation at the Air Force-Marquardt Jet Laboratory at Van Nuys. Other units are scheduled to be installed at Langley Field, Va., for the National Aeronautics and Space Administration, and at Edwards Air Force Base for the Air Force Flight Test Center.

A 40-in. tube filled with helium and neon is the basic part of the continuously operating optical maser



Microencapsulation in effect makes soluble materials insoluble, isolates mutually reactive substances, or prevents loss of volatile materials by evaporation. The capsule structure can be broken down, when desired, by heat, pressure, grinding, or dissolving, or even enzymatic action.

Microencapsulation

CAPSULES as small as 1/25,000 in. in diam have been used as miniature "packages." Although the technique is relatively new, and one of the original processes was based on scientific studies of how living cells are formed, it has already led to a surprising number of industrial applications.

The National Cash Register Company has patented a process which involves depositing a polymer film (originally gelatin and gum arabic) around a material to be encapsulated. According to the January-February, 1961, issue of *Research for Industry*, issued by the Stanford Research Institute, National Cash Register first developed microcapsules of a colorless dye that gave color on contact with a reagent.

A coating of the minute capsules was applied invisibly to a sheet of copy paper, so that ordinary writing or typing pressure ruptured the capsules to release the dye, providing a replacement for carbon paper.

Since then, a host of possible uses for microencapsulation have been under development and National Cash Register has adopted a broad industry licensing policy under their patents. Stanford Research Institute has agreed to conduct research in capsular technology for National Cash Register licensees who desire to take advantage of the wide technological background in microencapsulation available at Stanford Research Institute. Work at Stanford Research Institute includes fundamental research in encapsulation for both industry and government clients as well as capsule development for specific applications.

A look at some of the properties of microcapsules suggests ways in which the process might be applied. To begin with, a wide variety of substances can be encapsulated, including solids or liquids, and possibly gases under pressure. The capsule structure can be broken down, when desired, by heat, pressure, grinding, or dissolving, or even enzymatic action. Encapsulation yields the seeming paradox of making soluble materials nonsoluble, liquid or gaseous materials solid, and of giving other reversals of properties. The capsules make it possible to keep two or more mutually reactive substances physically separated even though they are intimately mixed. Likewise, materials that are toxic or allergenic can be handled more safely while enclosed in capsules.

Microcapsules can be produced in dry, granular form or as aggregates in a plastic or self-sustaining mass. Or they may be incorporated in a liquid, solid, or semisolid mass of other material.

To mention only a few of their many suggested applications, water-soluble capsules containing pesticide or fertilizer could release their chemicals slowly over a period of time to prevent loss by evaporation or decomposition. Flavors and aromas in foods that are lost by their high volatility can be encapsulated and added to mixes. Mutually reactive agents in solid rocket fuels might be enclosed in microcapsules that are broken down by the heat of firing. Even the capsule wall could contain a catalyst to speed the chemical process when ready.

Among the controllable variables in the microencapsulation process are capsule size, contents, wall material, wall strength, wall permeability, wall additives, mass state, and the means and rate of release. These variables make it possible to tailor the capsules to fit the particular use. Therefore innumerable combinations of variables can produce a wide variety of potential uses. With the liberal addition of that most important component, imagination, the microencapsulation process will be applied in a growing number of new ways in tomorrow's world.

Friction Welding

EVIDENCE that a layer of fluid metal is formed at the interface of metals being welded by the friction process was found in the first intensive American laboratory study of friction welding. Since the existence of the fluid layer had not been revealed in the few papers on friction welding thus far written, this finding is among the most important obtained in a study by the Central Research Laboratory, Stamford, Conn., of American Machine and Foundry Company.

Friction welding can be defined as a process for converting the mechanical energy of two metal, plastic, or ceramic objects revolving or sliding in contact with one another into thermal energy, which under proper conditions and controls results in a weld of the two (or more) objects at the place of contact. The concept of friction welding is not new—some patents based on the concept go back to the late 19th century. However, there has been very little basic scientific study or understanding of the process.

Friction welding has been under more intense study abroad since publication of a work by V. I. Vill of the USSR in 1957. Since then, about a dozen papers and summaries have been published in Russian, Polish, and Czechoslovakian journals. Most of this early work, according to the AMF researchers, may be characterized as pragmatic or "instinctive" explanations of the phenomenon of friction welding.

Early explanations or theories may be summarized thus: Friction welding is a variant of pressure welding and the weld is made during plastic deformation of the abutting surfaces. The two objects revolve or oscillate against each other until the heat of friction produces the temperature required for pressure welding. At this point, motion is stopped and the two pieces are held together by pressure to form a weld.

AMF's study has led to a more refined explanation of the process and the basic parameters under which the weld phenomenon takes place. A study of the records of the highly instrumented laboratory friction-welding machine built by AMF produced data about the weld phenomenon which, in the opinion of the researchers, are more revealing than the Russian reports. One of the elements of a theory proposed by them is the postulation of a layer of fluid metal formed at the interface of the two objects, particularly for the case of alloy steels. This layer acts as if it were a hydrodynamic thrust bearing or extreme-pressure lubricant. Evidence of its existence occurs simultaneously with high quality welds in alloy steels and certain other metals.

The Central Research Laboratory of AMF also investigated, derived, and measured the basic parameters and machine requirements for friction welding such as: speeds of rotation; machine rigidity; time and weld-cycle sequence; torque; pressure; temperature; heat-treatment, grain growth, metallurgy; and weld geometry.

With the laboratory machine, friction welding of a variety of materials was investigated including carbon, alloy and stainless steels, brass, aluminum, copper, and zirconium.

Friction-welding studies will be continued at AMF in order to refine and elaborate theories, refine the determination of the parameters, and to study the friction welding of dissimilar metals and other materials.

The friction-welding program was conducted by Milton B. Hollander, Assoc. Mem. ASME, head of the Mechanics Department of AMF's Laboratory.

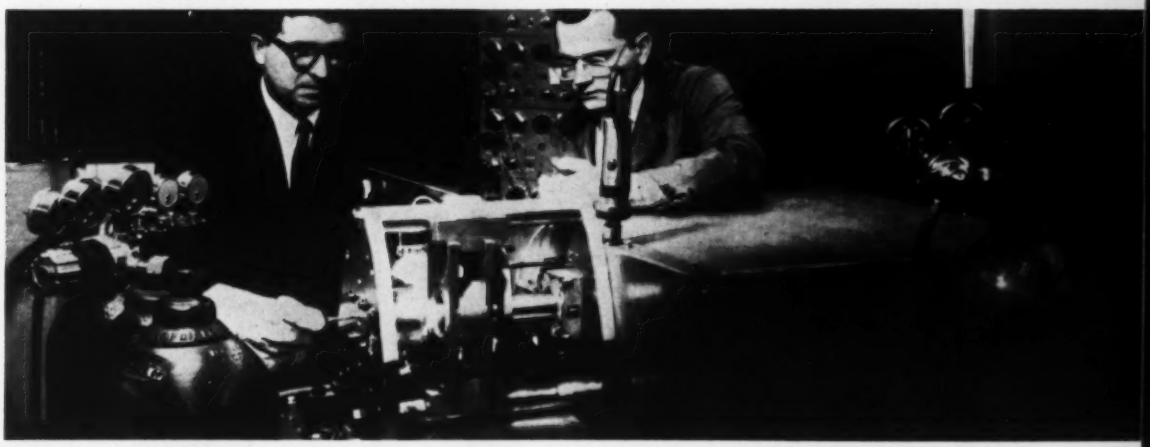
Ultrahigh Magnetic Fields

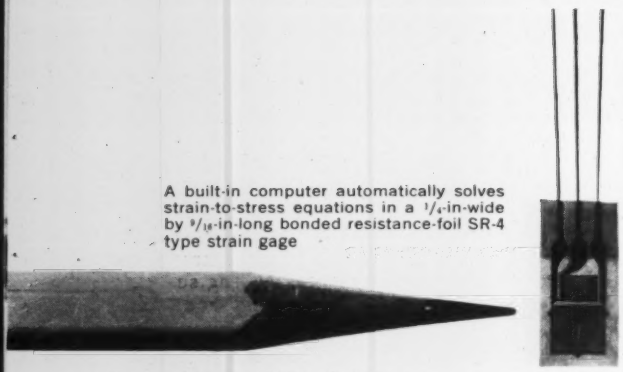
THE feasibility of producing extremely high magnetic fields with superconducting solenoid magnets has been demonstrated by Bell Telephone Laboratories. A superconducting compound of niobium and tin (Nb_3Sn), fabricated and reacted by special metallurgical techniques, was utilized in the latest experiment. This compound was first discovered at Bell Labs in 1954.

Although it has been realized for many years that it is possible to produce magnetic fields with superconducting solenoids, the materials that have been tried in the past would only sustain fields of a few thousand gauss. At larger magnetic fields the superconducting properties disappear. With the new compound, steady-state magnetic fields of 88,000 gauss are possible.

Indications are that the niobium-tin material will sustain fields of 100,000 gauss while carrying electrical currents of 100,000 amp per sq cm of cross section.

M. B. Hollander and F. Camps-Campins, both Assoc. Mem. ASME, observe the friction welding of high-carbon steel in a laboratory study of the basic mechanism





A built-in computer automatically solves strain-to-stress equations in a 1/4-in-wide by 9/16-in-long bonded resistance-foil SR-4 type strain gage

Computerized Strain Gage

An SR-4 bonded resistance-foil strain gage—with a built-in computer that solves general strain-to-stress equations automatically—has been developed by the Electronics and Instrumentation Division, Waltham, Mass., of Baldwin-Lima-Hamilton Corporation.

The new gage will greatly simplify the obtaining of stress readings in a wide range of testing and measuring applications by automatically eliminating the need for tedious, time-consuming calculations of stresses from the strain indications.

Electrical responses which are proportional to either stress or strain are provided at the discretion of the user by using two independent axial strain-sensing elements oriented 90 deg apart.

One element measures the conventional strain. The other element acts as the automatic computer by rejecting the axial component of strain caused by stress in a transverse direction. The combined elements then respond only to that component of strain which is produced by stress in the axial direction.

Through use of a simple switching arrangement, with the three-wire system provided, three measurements can be made easily and rapidly: (*a*) Strain along the principal sensing axis, (*b*) stress along the principal sensing axis, (*c*) strain along the transverse axis.

This unique versatility is provided by proper design of grid configuration and a controlled resistance ratio between the two elements. The ratio depends primarily on Poisson's ratio of the material for which the gage is designed and calibrated.

The new gages are available with a phenolic-base construction and Constantan foil—with resistance ratios and temperature compensation for mild steels, stainless steel, and aluminum.

Gages Presently Available

Gage	Temp compensation expansion coefficient	Stress measurement, Poisson's ratio	Nominal resistance, element 1/ element 2
FAB28-S6.....	6 (mild steel)	0.28	98/350
FAB28-S9.....	9 (most stainless steels)	0.28	98/350
FAB33-S13.....	13 (aluminum)	0.33	115/350

In each instance, nominal gage resistances have been selected for compatibility with electronic strain-measuring instrumentation—for use with gage resistances between 60 and 500 ohms or higher.

The gages can be bonded easily with such room-temperature curing cements as BLH EPY-150 epoxy, Eastman 910 cyanoacrylate for applications up to 150 F, or BLH EPY-400 epoxy for elevated-temperature applications up to 450 F.

Continuous-Display Frequency Counter

By the use of a storage system, inefficient intermittent display is eliminated in the Type 1130-A Digital Time and Frequency Meter made by General Radio Company, West Concord, Mass.

Previous counters have been limited to an efficiency of 50 per cent at best by requiring alternate accumulation of information and then display. With the new system a count is displayed continuously while a new count is being accumulated in the computer-memory-type storage system. At the end of each counting interval, the new count is transferred to the display in a brief 1000-microsec interval.

Frequencies from decacycles to 10 megacycles are measured with a precision of 0.1 cps, periods from 10 microsec to 10^7 sec with a precision of 0.1 microsec, and time intervals from 1 microsec to 10^7 sec with a precision of 0.1 microsec. The Type 1130-A can also be used to count random events, measure frequency ratios, compute phase shift, and measure characteristics of pulse waveforms.

The design has drawn extensively upon computer techniques and components. High reliability has been insured by the use of computer-grade tubes throughout the instrument-frame grid types where suitable. All components are severely derated and premium-quality connectors are used. Circuits have been designed to operate properly under extensive variations and degradation of tube parameters without complex regulated plate and heater power supplies. Only one lightly loaded regulator circuit is used. This provides maximum stability of the crystal-controlled, time-base oscillator.

Modular construction has been used to simplify maintenance. Every tube circuit is on an etched-circuit board, which can be removed quickly for repair or replacement, and test points are available at marked panels on both sides of the instrument.

The use of internal storage permits easy adaptation to analog graphic recording. A simple digital-to-analog converter accessory provides a d-c output of 0.1 per cent accuracy and linearity, corresponding to any three consecutive digits of the counter display. This output will drive graphic recorders without the need of an intermediate, expensive electromechanical storage system.

The Type 1130-A Digital Time and Frequency Meter not only provides continuous display by using a computer-type storage but is easily assembled

Materials Briefs

▶ Deep-Penetration Pressure Treatment of Wood

LIQUEFIED gas in a pressure vessel is used by the Technical Department of the Wood Preserving Division of Koppers Company, Inc., at Orrville, Ohio, to deposit preservative chemicals in the fiber of wood. Called Cellon, the treatment does not change the color, weight, size, strength, workability, or glueability of the wood but provides excellent resistance to decay and insect attack. According to the company, it provides the deepest penetration of any wood-preserving process yet devised.

Pentachlorophenol, deposited as a dry crystalline salt at the rate of 0.3 lb per cu ft of wood, is the preservative. Nonsoluble in water, it cannot be leached and evaporates at an extremely slow rate. Freshly cut green wood can be readily treated and the finished product can be readily clean finished or painted.

▶ Metal-Powder Microspheres

Commercially pure ingot iron and zirconium with 2 per cent tin are now available in the form of spherical powders, 20 to 150 microns in size.

The solid, polished-surface microspheres are being produced by the Crystal Products Department, Linde Company, Division of Union Carbide Corporation, East Chicago, Ind., with their recently developed spherodizing process. The new products are in addition to the currently in-stock line of aluminum alloys, nickel, Nichrome V, No. 316 stainless-steel, copper, and tungsten microspheres.

Although not in stock, some platinum and 99.999 per cent pure aluminum microspheres also have been processed.

▶ Rhenium-Molybdenum Alloys Commercially Produced

The first commercial production of rhenium-molybdenum alloys has been made by Chase Brass and Copper Company, Waterbury, Conn. The high-strength refractory alloy has good ductility for specialized applications and considerable advantages over both pure rhenium and pure molybdenum.

Rhenium, an extremely dense metal, has a melting point (5756 F) higher than any other metal except tungsten. Strength, ductility, and electrical characteristics are excellent even at elevated temperatures.

Molybdenum is a refractory metal with 2600-C melting point that becomes embrittled in the recrystallized condition below approximately 20 C.

The successful alloying of rhenium and molybdenum provides better mechanical properties than those of either metal alone at considerably lower cost than pure rhenium. Elevated-temperature strength exceeds that of molybdenum while very good ductility is retained as far as the cryogenic temperature range without evidence of embrittlement.

Rod, wire, and strip products are now available from Chase in 50 Re-50 Mo and 40 Re-60 Mo (weight per cent) alloys.

▶ Molecularly Bonded Stainless-Clad Aluminum

Aluminum sheet has been successfully joined to stainless steel by molecular bonding. Extensive field testing has been conducted on hundreds of samples of the dual metal by Fairmont Aluminum Company, Fairmont, W. Va., a subsidiary of the Cerro Corporation, New York, N. Y. The new material will be available in limited quantity until a $10-million plant-expansion program is completed.

Although stainless steel and aluminum have been joined by various casting methods, this is the first successful molecular bond in sheet form of these two dissimilar metals. Normally, ferrous and nonferrous metals have little affinity for each other.

Stainless-clad aluminum has potential uses as a construction material for liquid-storage tanks or for automotive parts normally made of stainless.

The resistance to corrosion and staining, and strength of stainless are combined with the lightness, thermal conductivity, and formability of aluminum.

There are no technical limitations as to the gage of the stainless clad, nor are there any fixed content ratios of stainless to aluminum. In a typical sheet the weight would be only half that of a solid stainless-steel sheet. The material lends itself to deep drawing, stamping, trimming, beading, spinning, arc welding, stud and spot welding, brazing, coining, and many surface-finishing operations.

Fairmont is licensee for the process for bonding the stainless steel and aluminum which was developed by Composite Metals Products, Inc., of Washington, Pa.

Nuclear Briefs

▶ Yankee Cost $7 Million Less Than Expected

TOTAL costs for construction, core, and start-up of the Westinghouse-built Yankee pressurized-water reactor at Rowe, Mass., will probably be at least $7 million less than the $57 million officially estimated. All target dates have also been bettered by a month or two.

According to the March, 1961, *Forum Memo* of the Atomic Industrial Forum, Inc., this is the first U. S. nuclear power plant to cost less than estimated. It may make possible 12 to 14-mill power with the first or second core rather than the later ones, as previously anticipated.

▶ DCX-2 to Be Constructed at ORNL

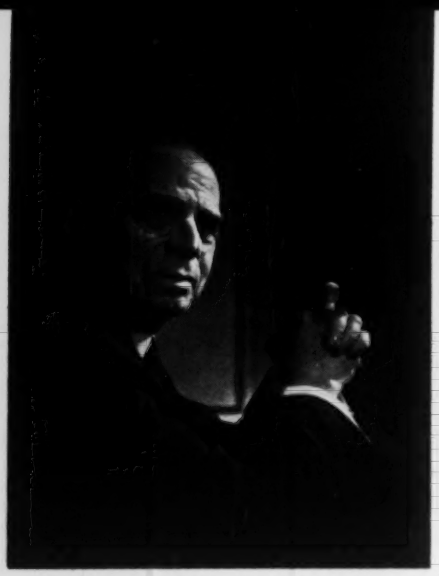
The Direct-Current Experiment No. 2, DCX-2—an advanced-design experimental facility which may be capable of developing temperatures in the billions of degrees—is being constructed at the Oak Ridge National Laboratory.

It will be designed on the same basic principle as its predecessor, DCX-1, which has been in operation for three years. Like DCX-1, the new facility will be a "hot-ion" injection system in which ions are accelerated by high voltages before being introduced into the device. In DCX-2, ions will be injected at 600,000 electron volts, a much greater rate than in DCX-1. Under certain conditions, this would be comparable to a temperature of more than 3 billion C.

After injection, the particles will be trapped in a strong magnetic field which will be much more uniform in the center of the new device than in the old one.

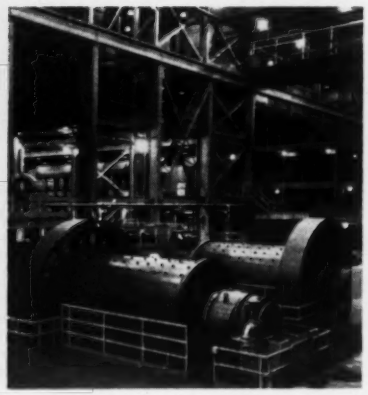
Union Carbide Corporation, which is carrying out the Oak Ridge portion of the controlled thermonuclear research program for the AEC, will fabricate those components of DCX-2 which are highly specialized.

The modification and construction work, which will cost about $650,000, is being done by The H. K. Ferguson Company. The total cost of the project will be about $1.6 million and DCX-2 is expected to be in operation by fall.



Dr. John F. Thompson, Honorary Chairman, Chairman of Executive Committee, INCO, the man who gave his name to this INCO project

Part of the crushing and grinding section of the highly automated mill



Flotation machines separate the ore at the Thompson mill

Nickel for the New Alloys

In the far north, 100 miles west of Hudson Bay, a "flying magnetometer" spotted an ore deposit. There the International Nickel Company of Canada, Ltd., built a mine, a plant—and a modern town.

AT NOON on March 25, 1961, in a modern plant sticking up in the Canadian wilderness, 150 engineers, editors, and officials witnessed the dedication of the Thompson nickel mine of the International Nickel Company of Canada. This is a report on the new mine, the metal called nickel (which turns ordinary steel into remarkable steel), and an engineer whose long career was crowned by having a town named after him.

The engineer is Dr. John F. Thompson, 80-year-old Honorary Chairman of the Board of INCO, still active at the company's Wall Street headquarters. In 1906, Dr. Thompson, then an assistant in metallurgy at the school of mines, Columbia University, joined INCO to design and operate the company's first research laboratory. Just fifty years later he gave his name to INCO's new mine and community in north-central Manitoba. The Thompson project is now the second largest nickel operation in the free world—next to INCO's operation in the Sudbury District in Ontario.

The Metal That Makes the Difference. Nickel comes out of the textbooks as a hard, malleable, ductile metallic element, nearly silver white, capable of a high polish, and resistant to oxidation. Its first great engineering application appeared in the nickel-steel armor plate of battleships in World War I. In this modern era of high-temperature engineering, stainless steel (essentially a nickel alloy) takes 30 per cent of all the nickel used in the U. S. Another 5 per cent goes into "super alloys" for turbine blades. The Boeing 707 has half a ton of nickel in each of its engines.

The Thompson project began when an airplane, trailing an electromagnetic instrument, discovered the Thompson ore body (INCO pioneered the use of the "flying magnetometer"). Then came diamond drilling —and the decision to develop the mine. Cost of the exploration: Some $10 million. Fifty-six thousand linear miles of aerial survey had been flown, and hundreds of thousands of feet of test holes had been diamond drilled. The rock formation in which the nickel was found is part of the Precambrian Shield, a formation of precambrian rock that comes to the surface in the Canadian wilderness. (Such rocks contain no fossil remains, indicating that they probably were here before life itself.)

In the winter of 1956–1957, a rail line was being thrust toward the mine site from the Canadian National track that terminates at Churchill on Hudson Bay. Another year and the rail line would reach the site—but INCO would not wait. That winter, INCO's tractor trains moved in 30,000 tons of material. The "snowball express" ran 24 hr a day, seven days a week, from a marshalling area at the railway, to Thompson. The 70-mile round trip over snow-covered muskeg and frozen lakes took 14 hr, in temperatures down to −60 F.

The cat train brought in power shovels, cranes, fuel-oil tanks, building materials, and all the other material needed to turn a wilderness into an industrial center. On Oct. 20, 1957, the last spike was driven in the 30-mile spur linking Thompson with the Hudson Bay Line. The mechanized equipment of modern mining began moving into place. In 1958, they built the first house in the carefully planned town of Thompson.

While plant and town were taking shape, a third project got under way some 60 miles to the northeast—a hydroelectric development on the Nelson River, the Kelsey Power Plant. The Thompson development is an all-electric plant, its furnaces getting their heat from the power lines from "Hydro." Surprising as it may seem in that frozen area 400 air miles north of Winnipeg, the Kelsey power station will produce hydroelectric power every day in the year. Its five units have a total capacity of 210,000 hp, with provision for expansion.

The Thompson ore bodies are being mined principally by horizontal cut-and-fill mining. The deposits contain nickel sulfide ores, with relatively small quantities of copper. Minor quantities of cobalt, platinum, palladium, gold, and silver are also present in the ores. The mill will treat 5000 tons of ore per day, brought up from a depth of 2100 ft.

An Integrated Plant. This is the world's first completely integrated nickel-producing facility. Once the ore has

A starting sheet is lowered into an electrolytic tank

Right, the modern town of Thompson rises out of the Canadian wilderness. **Below,** the plant site, the first completely integrated nickel plant, and the second largest in the free world.

come up in the "skips" and been tipped into the storage bins, two stages of crushing are followed by fine grinding. The valuable minerals are then separated out, using the flotation process. The nickel concentrate is pumped to the smelter, where electric furnaces take over the further separation of nickel sulfide and slag.

It almost goes without saying that this is a highly automated operation, a plant as modern as the jets and rockets in which nickel is so widely used. In the quiet control room there are two large control panels, one for "Hydro," one for INCO. The mill runs entirely by automatic control.

The molten nickel sulfide—"matte"—is cast into refinery anodes. These anodes look like flat gravestones. In the refinery, they are placed in plating tanks and connected, as anodes—right next to cathode "starting sheets" of pure nickel. Nickel is deposited by electrolysis onto the starting sheet, producing a thick plate of pure nickel which is then sheared into widths according to customer requirements and shipped to markets in Canada, the U. S., and the United Kingdom.

Curiously, Thompson is closer to foreign markets than to the U. S. This is because of its nearness to Churchill, the seaport on Hudson Bay. Although the port of Churchill is open to navigation for only six weeks of the year—from about July 15 through August—tremendous quantities of material are stockpiled for shipment. Nickel will be so stockpiled and shipped. In recent years, Western Europe has become a prime user of nickel. At least 75,000,000 lb of nickel a year will emerge from the Thompson refinery.

INCO had one stroke of luck. At the spot where they wanted to sink their mine shaft, the rock formed a plateau, ideal as a foundation for the plant buildings (the smelter is one of the heaviest buildings in Canada). The plant covers 250 acres, with a modern office building housing the administration, engineering, and geological departments as well as the metallurgical laboratory. This last must have been a special delight to Dr. Thompson, founder of INCO's first laboratory, as he made the tour of the plant with the visitors for the dedication.

From the plant, it is two miles to the town. INCO is determined to make Thompson a place in which families can live in suburban comfort and security. All the homes and public buildings are modern to the last degree. Walk into the Hudson Bay Company store and you could imagine you were in Wanamaker's in Westchester. The school, the hospital—right out of modern suburbia. Of course it's a mite chilly, and on March 25 the snow was deep. But it was noted that there were boats as well as cars in the driveways of homes. Boating will be a popular sport: There are lakes nearby, and the town is situated on the picturesque Burntwood River.

Ultimately, this should be a town of 8000 population. The plant now employs 1800, will soon raise this to 2300.

Note to Machine Designers. What is the future of nickel? F. L. LaQue, an INCO vice-president, points out that every time we raise stress or temperature we must upgrade the metal by putting in nickel.

"It is a fact," he said, "that the compact cars require more nickel in their steel than the larger cars—smaller gears require better steel. The improvement in chrome plating for cars is primarily a matter of more nickel. The coming antismog devices will require nickel—afterburners run hot."

The same holds true for low-temperature applications. The containers for liquid oxygen in missiles, for oxygen in steel plants, for the transportation and storage of natural gas in liquefied form (methane)—all require more and more nickel.

These facts help explain why INCO ventured $130 million in the Thompson project. The Hon. Duff Roblin, Premier of Manitoba, said at the dedication ceremony: "Now that a lump of ore has replaced the fur pelt as the symbol of the richness and the potential of this great region, we pay tribute to a company of mining adventurers—men who . . . have paved the way for the permanent development of this frontier land."

But the dominating personality at the dedication was that of Dr. Thompson, the wiry, active, senior engineer who, at 80, sees this project wearing his name. Privately, he offered an explanation of how you get to the top, a philosophy that young engineers with management aspirations might ponder.

"You take care to hire men who are smarter than you are," he said. "That way, you always get pushed out of your job—upstairs, of course."—*Maurice Barrangon*

Fanjet Engine.
Looking into the teeth of the American Airlines Boeing 707 "Astrojet." The forefan is a multi-bladed, shrouded propeller, moving a greater volume of air at a slower speed than the pure jet. (Here, it is a development of the Pratt & Whitney JT-3 engine.) Result: Added thrust, increased propulsive efficiency, increased speed.

PHOTO BRIEFS

M. BARRANGON

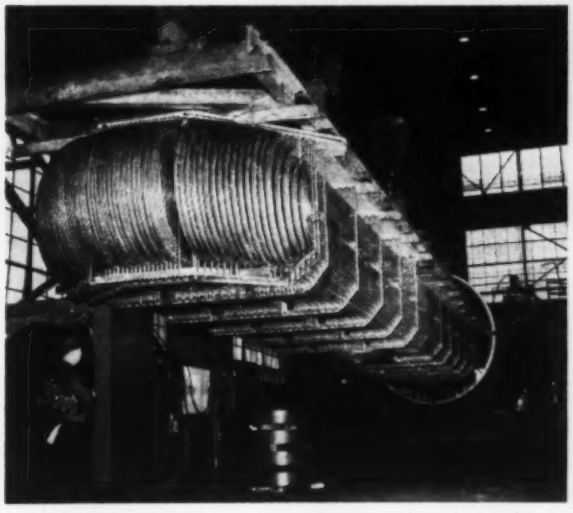
Steel-Capped Aluminum Piston.
This aluminum piston is capped with a thin layer of stainless steel, a design produced by Aluminum Company of America in its Cleveland laboratories. Not yet engine-tested, the piston has been sectioned for study of the pressure bond, an Alcoa process.

Bridge Conveyer. Near Pasco, Wash., this 930-ft bridge was built to haul sand, gravel, and rock for the Ice Harbor Dam on the Snake River. The 2400-ft belt, by B. F. Goodrich Industrial Products Company, carries 660 tons per hr at 300 fpm.

Electronic Highway. A Dodge Lancer makes a test run on a road with no traffic problems. All types of engine and load conditions hit the car through powerful dynamometers, for sound and vibration study.

Thermoelectric Couples. At Westinghouse laboratories, tests are performed on some of the thousands of thermoelectric couples for a unit said to be the largest thermoelectric generator ever built. This is an experimental project for the U. S. Navy.

Unique Steam Generator. This steam generator, built by Combustion Engineering, Inc., at Chattanooga, Tenn., is 57 ft long, weighs some 170 tons, and has 20 miles of stainless-steel tubing. It's the first of ten built for AEC's Hanford Works.

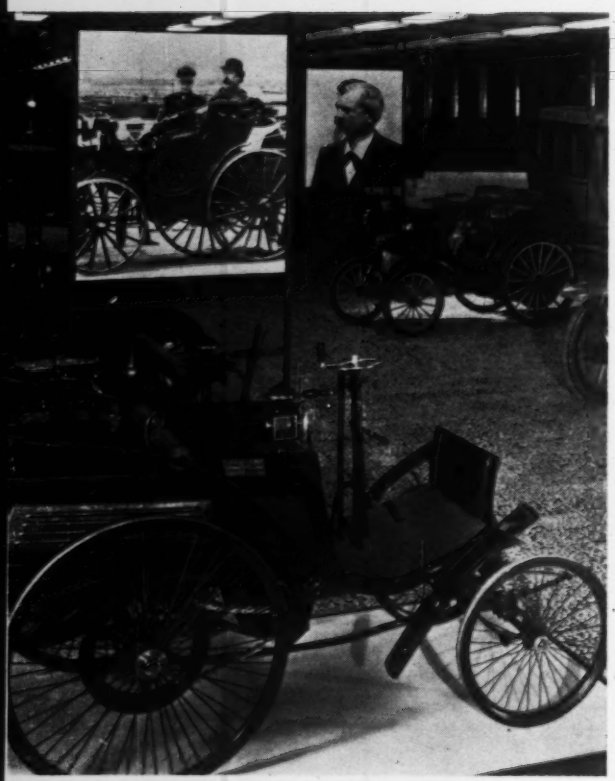


Engineering Progress in the British Isles and Western Europe

J. FOSTER PETREE
European Correspondent

EUROPEAN SURVEY

Model of the new funnel design for the Atlantic liner, "France." Smoke will emerge from ends of "wings" instead of from top.



The Daimler-Benz automobile and engine museum at Stuttgart-Untertürkheim, Germany, which has opened on the 75th anniversary of traffic motorization. In foreground is 1894 model.

Funnels of the "France"

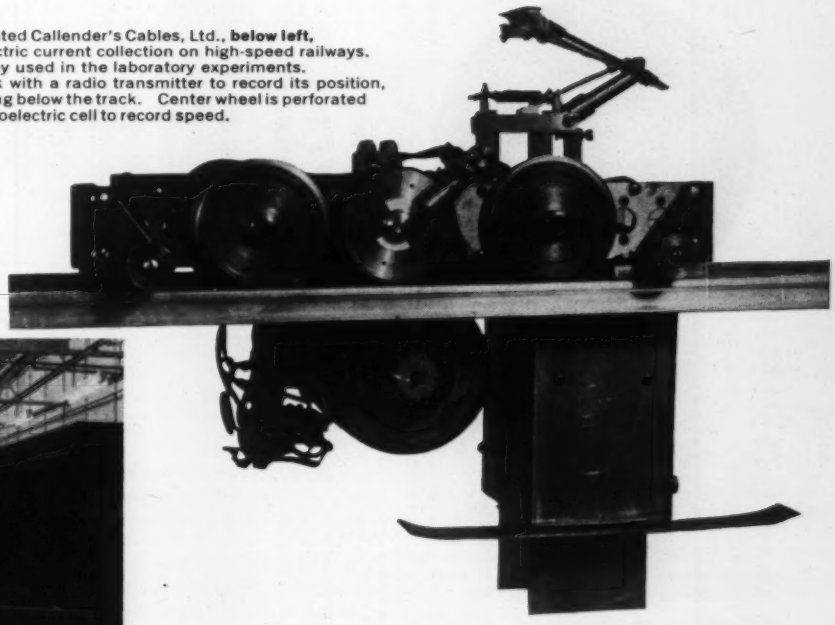
THE French Line's new Atlantic liner "France," the longest liner in the world, now well advanced toward completion at St. Nazaire, will have funnels of a unique design. The smoke, instead of coming out at the top, will emerge from the ends of "wings" like those of a short-span aircraft. The design is the result of a long series of wind-tunnel experiments at Poitiers, France, which showed conclusively that, to avoid soiling the afterdecks with soot, the smoke must be discharged well away from the mass of the funnel itself, and as high above the decks as possible. The height of the forward funnel will be 54 ft above the deck. At its base it will measure 66 ft fore and aft, and 32 ft wide. The span of the "wings" is 63 ft.

Daimler-Benz Museum

GOTTLIEB DAIMLER (1834–1900) built his first gasoline engine in 1883, and in 1886 Karl Benz (1844–1929) built his first automobile, fitted with a two-stroke engine of the type that he had introduced in 1878. To mark the 75th anniversary of the advent of the internal-combustion engine on common roads, the Daimler-Benz firm has opened a new historical museum at Stuttgart-Untertürkheim, Germany, in which has been gathered a unique collection of automobiles, aircraft engines, and motorboat engines, as well as a range of portraits of the pioneers themselves. These include Fraülein Mercedes Jellinek, daughter of Daimler's associate, Emil Jellinek, for whom the Mercedes car was named in 1901. For many years the two firms were separate, but they merged into Daimler-Benz A.G. in 1926.

Correspondence with Mr. Petree should be addressed to 36 Mayfield Road, Sutton, Surrey, England.

Laboratory at British Insulated Callender's Cables, Ltd., **below left**, for research into overhead electric current collection on high-speed railways. At **right** is the electric trolley used in the laboratory experiments. It runs on a closed circuit of track with a radio transmitter to record its position, velocity, and acceleration, hanging below the track. Center wheel is perforated so that light can strike a photoelectric cell to record speed.



Current-Collection Research

THE problems of collecting electric current by pantograph from overhead conductors are of crucial interest to many European railroads, but they have been tackled hitherto by purely empirical methods. The stimulus provided by the decision of British Railways to electrify their mainline services, and the consequential prospect that a number of systems in other countries might thereby be encouraged to take another look at mainline electrification, have led British Insulated Callender's Cables, Ltd., of London, England, to set up a special laboratory for research into current collection at high speed.

Basically, the problems are mechanical—to insure at all times and at all speeds a uniform upward pressure of the collecting strip against the conductor wire, irrespective of the variable rigidity of that wire between its supports, of changes in its inertia and in the height above the track, of wind effects, and of the aerodynamic resistance of the pantograph. The original idea was to make full-scale experiments, but cost was one of the difficulties that made this impracticable. Also, no suitable length of track could be allocated for the purpose. B.I.C.C. decided, therefore, to experiment with a scale model that would reproduce all the characteristics of the full-sized equipment at simulated speeds up to at least 100 mph.

The laboratory is 200 ft long and 20 ft wide. It contains a closed circuit of track with straight sides 144 ft long, joined at the ends by curves of 14 ft diam. The actual track is of standard model railway $^{5}/_{8}$-in. aluminum flanged rail, attached to board carried on a steel sectional framework at a height of 4 ft from the floor. The test sections, 80 ft long, are situated in the middle of the straight sides and are contained in temperature-controlled housings. The traveling bogie carrying the pantograph is about 12 in. long. Its full speed of nearly 18 mph corresponds to 100 mph on a full-sized train. The model pantograph is made of brass and dynamically is as nearly as possible a true-to-scale copy of the Stone-Faiveley prototype used on British Railways. In its suspension, the conductor wire follows the full-sized equipment, but to simulate accurately the elastic and rigidity constants, and to provide a truly equivalent mass, the conductor is made of a fine wire on which are fixed closely spaced brass beads, electrically soldered in position. To avoid "ripple" in the current collection, the spacing is such that the pantograph contact strip always rides on three beads.

The position, velocity, and acceleration of the pantograph trolley are continuously recorded by means of high-frequency signals from a radio transmitter on the trolley to a receiver aerial wire carried by the supporting structure. Velocity is measured by a beam of light focused on a photoelectric cell through holes equally spaced around the periphery of an extra wheel on the trolley. The pulses produced are read on a meter calibrated in fps. By taking the output through a differentiating circuit to another meter, acceleration can be measured. Position is recorded by a beam of light directed downward and reflected into a photoelectric cell from small polished aluminum blocks on the supporting structure. The drive is by a 50-volt d-c electric motor. The movements of the conductor wires and their supporting catenaries are observed by various means, including high-speed cinematography and a method that registers the position of a wire by casting its shadow onto a photoelectric device. So far, the experiments have been in progress only a few months, but results show that the method of approach is correct and offers promise of valuable guidance in the design of overhead equipment.

Substance in Brief of Papers Presented at ASME Meetings

ASME TECHNICAL DIGEST

Aviation

Calibration Techniques in Ultrahigh-Pressure Apparatus . . 60—WA-178 . . . By F. P. Bundy, General Electric Company, Schenectady, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.**; available to Oct. 1, 1961).

Within the past few years several kinds of apparatus have been developed which are capable of maintaining, simultaneously, pressures up to about 100 kilobars and temperatures above 2000 C for periods of minutes or hours. This development has expanded tremendously the field of investigation of chemical reactions, phase changes, and physical properties of materials under extreme conditions. In order that the results obtained from these investigations may be compared properly with theory, and with the results of other methods of subjecting matter to very high pressures and temperatures—shock pressure-wave technique for example—it is important that the pressures and temperatures be known in absolute terms. The purpose of this paper is to present the origins of the pressure and temperature scales used in this field, to describe some of the calibration techniques, to point out some of the weaknesses and discrepancies existing today, and to suggest some ways in which improvements might be realized.

Use of a Centrifuge for the Precision Measurement of Accelerometer Characteristics . . 60—WA-195 . . . By S. R. Sporn, American Bosch Arma Corporation, Garden City, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.**; available to Oct. 1, 1961).

The large dynamic range to which accelerometers are subjected in a space-injection application requires that precision high "g" development studies be made. The only practical way of obtaining sustained, measurable accelerations in excess of 1g is by means of a centrifugal accelerator. The purpose of this paper is to describe the techniques which have been developed at Arma Division to process and interpret accelerometer linearity data obtained on the precision centrifuge. A basic output equation was formulated for an inertial quality accelerometer and areas of correction for some size anomalies that could occur were pointed out. In addition, a centrifuge acceleration formula, corrected for earth's rate, was developed. Interpreting this formula leads to the possibility of measuring earth's rate with an accelerometer.

The Performance of Gyroscopes in a Vibration Environment . . 60—WA-246 . . . By William E. Fellows, Assoc. Mem. ASME, Minneapolis-Honeywell Regulator Company, Minneapolis, Minn. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Rectilinear sinusoidal or random vibration, rotating acceleration vector, and sinusoidal rocking motions cause three different types of gyroscope error. The mechanism of the three errors shows that the usual description of vibration environment is grossly inadequate for assessing gyroscope performance. Four environmental parameters of sinusoidal vibration must be known to predict gyro error. These are magnitude, direction, frequency, and the time phasing between directional components of the vibration. Directional distribution must be known in addition to the power spectrum frequency distribution to assess performance in random vibration environment.

It is concluded that the possible gyro error is anisoelastic and, depending on gyro orientation with respect to the unknown axes, the error will be somewhere between zero and a known maximum.

The probability of either zero or maximum gyro error is nil, so it should not be necessary to assume the worst in gyro performance but, because of the lack of rectilinear, rotating-vector, and angular-oscillation environmental information, most component specifications require that the gyro meet anisoelastic performance figures when tested under maximum environmental conditions.

Gyro Micro-Yield Measurements on a Precision Linear Vibrator . . 60—WA-247 . . . By Peter J. Palmer, Massachusetts Institute of Technology, Cambridge, Mass. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The precision linear vibrator is a testing device that subjects a gyro (or other test specimen) to a precisely controlled rectilinear sinusoidal vibration.

A precision linear vibration testing machine was designed and built at the M.I.T. Instrumentation Laboratory for evaluation of the effects on the performance of the M.I.T. single-degree-of-freedom floated integrating gyroscope of acceleration up to 5 G over a frequency range of 10 to 50 cps. The vibrator is described in detail. Recent hypotheses concerning the existence of gyro compliance in three-dimensional form are examined, and a detailed analysis of gyro test data is presented in an unclassified manner.

The objectives of the tests on the precision linear vibrator were: (*a*) To measure the compliance coefficients predicted by theory to exist; and (*b*) to check for nonlinearities; that is, to determine whether or not classical elasticity theory applies to the single-degree-of-freedom floated gyro.

The data indicate the existence of compliance coefficients that are functions of the applied acceleration squared and that may be used to describe the performance of a gyro in a linear acceleration and/or linear vibratory acceleration environment.

VTOL observation vehicle, **above,** with two fuselage-mounted lift fans. Fan rotor, **right,** is a single-stage axial-flow compressor driven by a turbine that is mounted at the tips of the blades. The rotor assembly has an over-all diameter of 72.51 in. (60—WA-224).

A Tip-Turbine Driven Lift Fan for VTOL Aircraft . . 60—WA-224 . . . By A. P. Adamson, Mem. ASME, and B. H. Rowe, General Electric Company, Evendale, Ohio. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

During the past few years the initial phases of the development of an advanced propulsion system designed to give aircraft the capability of vertical take-off and landing (VTOL) have been completed.

From studies performed in 1957 by the Flight Propulsion Laboratory Department of General Electric in connection with a contract with the Transportation Research Command of the United States Army, one of the systems that showed a considerable amount of promise was a convertible one that used the jet engine for normal flight and a lift fan driven by turbine buckets mounted at the tips of the compressor for take-off and landing.

This paper presents the engineering philosophy inherent in the design of the lift fan. Included are some of the results of full-scale testing in the static test facility at Evendale, Ohio, and the wind-tunnel tests at Ames in California.

The Application of the Pinch Process for Space Propulsion . . 60—WA-254 . . . By Irving Granet, Mem. ASME, and William J. Guman, Republic Aviation Corporation, Farmingdale, L. I., N. Y. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

A "pinch" can be characterized as a shock producing electrical discharge propagated by the presence of a self-induced magnetic field. This process has been used in thermonuclear work to obtain extremely high temperatures by converting the kinetic energy of the bulk motion to thermal energy.

The electromagnetic pinch phenomenon has been the subject of considerable research in recent years because of its possible application for achieving a sustained thermonuclear reaction. For such a reaction it is desired to impart energy to a plasma with the intent of obtaining a maximum internal (random nondirected) energy. When this process is applied to a propulsion system suitable for space application, the mode of operation differs from the fusion program since the primary object is to obtain a maximum directed thrust. Two thrust-producing possibilities suggest themselves, one of which is to expand the heated stagnant plasma through a nozzle, the other is to conserve the pinch motion. This latter technique is shown to be the more desirable mode of operation and the principle has been proved in the laboratory.

High-Pressure Research in Metallurgy . 60—WA-271 . . . By John E. Hilliard, General Electric Research Laboratory, Schenectady, N. Y. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The recent development of equipment capable of simultaneously attaining ultra-high pressures and temperatures has opened up a new field of research in metallurgy.

There are two contributions high-pressure research can make to metallurgy. One is its use in the manufacture of alloys having properties otherwise unobtainable, the other is its use as a research tool to advance our knowledge of the atmospheric-pressure behavior of metals. For either application it is necessary to know the effects of pressure on the basic properties of metals, and the existing experimental data have been surveyed with this fact in mind.

By way of illustrating the applications of such research, this paper reviews recent experimental work on the effect of high pressures on the over-all properties of alloys and also on the more elementary properties, such as diffusion, thermodynamics, and defect concentration.

Automated Maintenance and Airline Economy for Supersonic Aircraft . . 60—WA-274 . . . By Eric R. Woods and Charles L. Blake, Convair, San Diego, Calif. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Convair is conducting studies and research directed toward the realization of a supersonic transport system. A key area in this effort is maintenance and support systems and their effect on the design of the vehicle. Inspection and maintenance are performed for the purpose of keeping the aircraft in optimum working condition and preventing operational failure. A number of systematized approaches to this problem are in use today. There is growing recognition, however, that the most desirable situation is to monitor sufficient data in each aircraft to permit reliable, economic planning of maintenance for each system.

The paper presents a general discussion of the economic aspects of these problems and the required automated approach. An automatic checkout system is illustrated. Functions for the selection, measurement, comparison, and analysis of data are shown. The key to the system is shown to lie in the memory and program management function. These are the elements that control what is selected, how it is tested and evaluated. This part of the system is basically a digital computer of the type employed for control and data processing. Associated with this system, and operating

under its control are any necessary stimulus generators and measurement transducers not convenient to integrate with the aircraft. These latter devices are primarily those associated with communication and navigation system. Finally, the provisions necessary to insure valid self-test and self-fault-isolation are included. Such a device can complete a comprehensive ground checkout of the airplane in a few minutes, including fault isolation, if this is desired.

An example of the way in which such a system might work is illustrated.

System Test Techniques for Mach 3 Aircraft . . 60—WA-280 . . . By A. C. Fulkerson, North American Aviation, Los Angeles, Calif.; and M. Pollack, Autonetics, a division of North American Aviation, Inc., Downey, Calif. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The embryonic Mach-3 jet transport is already within our sights now that such design configurations as North American Aviation's B-70 long-range jet bomber has seen the light of day.

In order to achieve high utilization rates of the Mach-3 airliner at high-performance confidence levels, a testing concept new to the airlines must be developed and implemented. However, economic considerations dictate that existing maintenance facilities, personnel, and equipment must be used with minimum alteration.

Taking the B-70 aircraft as a generic model of future Mach-3 transports, the authors demonstrate how the aircraft's existing airborne computer and tape recorder may be used routinely to initiate inflight tests and read out results. They suggest that comprehensive testing of the Mach-3 systems would require the following four distinct kinds of tests:

1 Confidence Testing. The ability of the systems to perform their functions is tested in the air or on the ground. This will be the only type of test normally performed on a layover inspection or service check.

2 Fault Isolation. A faulty unit detected by the confidence test is identified and replaced.

3 Periodic Inspection. Those portions of circuits not validated by the confidence tests are tested, and any possible preventive maintenance is performed.

4 Shop Maintenance. All required maintenance (other than overhaul) is performed on airborne units which are removed from the aircraft.

It is claimed that this approach to automatic checkout of these future aircraft will permit less frequent periodic ground checkouts and at the same time insure higher operational confidence levels over greater periods of time.

Tactical and Operational Advantages Attainable by Superperformance Aircraft Rocket Engines . . 60—WA-275 . . . By Charles R. Bell, Mem. ASME, Rocketdyne, a division of North American Aviation, Inc., Canoga Park, Calif. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The concept of using rocket engines to supplement primary power plants in aircraft is examined to determine if combat advantage can be gained.

Although this paper does not apply directly to commercial transport aircraft, it provides an explanation of the reasons for military programs to develop rocket engines for aircraft. Continuous comparison of this concept with other methods of thrust augmentation is made in terms of superperformance in take-off, climb, acceleration, and maneuvering versus weight and range penalties.

The present state of art indicates that in terms of rate of energy change, rocket augmentation at high altitudes in special cases can be superior to other methods such as water-mixture injection, variable inlet/exhaust geometry, and ducted arrangements.

It is concluded that the AR engine is an expediency for extension of the operational life of existing aircraft, as well as for integration into future aircraft designs for facilitating high-altitude operational flexibility. The complementary utilization of the AR concept in flight testing indicates this potential, and it is recommended for the objectives of air defense and strategic offensive missions in present and future tactical doctrines.

Heavy Presses in the Space Age . . 60—WA-288 . . . By L. W. Mayer, Aluminum Company of America, New Kensington, Pa. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

A brief description of the USAF heavy-press equipment operated by Alcoa is presented, and its utilization in support of the military aircraft program is described. Current missile and space-vehicle applications, such as the Mercury capsule's forged beryllium heat sink, are described. It is shown how the heavy presses, either alone or in combination, can be utilized to produce or to assist in producing large, thin-walled shells and tubular shapes for missile tankage and motor-case applications. The continued utilization of these large metalworking facilities on materials other than aluminum is described.

Electrical Propulsion Applications and System Requirements . . 60—WA-291 . . . By C. J. McDole, Rocketdyne, a division of North American Aviation, Inc., Canoga Park, Calif. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

A number of different types of electrical-thrust devices have been proposed for space applications. Of these, only two, the electrothermal or plasmajet engine; and the electrostatic, or ion, engine are presently playing a major role in the national electrical propulsion program. The discussion here is restricted to these two types of electrical-thrust devices.

In its simplest form, the plasmajet consists of an electric arc, a means of introducing the propellant into the arc chamber, and a nozzle through which the propellant which has been heated by the arc can be expanded to produce thrust. The ion engine consists of a source of charged particles, a system for accelerating these charged particles to high velocities, and a means of ejecting charged particles of opposite sign to those making up the ion beam at such a rate as to keep the vehicle electrically neutral at all times.

Missions such as manned and unmanned satellites, and planetary reconnaissance, to which these devices are very applicable, the work that must be done before these missions can be flown, and a tentative schedule, are discussed. The need for very careful system integration and extreme reliability is pointed out.

Corrosion and Deposits

The Role of Chemical Thermodynamics in Analyzing Gas-Side Problems in Boilers . . 60—WA-182 . . . By R. H. Boll and H. C. Patel, The Babcock & Wilcox Company, Research Center, Alliance, Ohio. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Power;** available to Oct. 1, 1961).

Gas-side fouling and corrosion in boilers (and gas turbines), as well as air pollution, are problems of increasing importance in the production of electrical power from coal. The composition of combustion gas is basic to the study of these phenomena for it transports various gaseous compounds, and in it may occur various chemical reactions which contribute to each of them.

Part 1 of this paper deals with equilibrium concentrations of 29 gaseous and five condensed constituents calculated for the combustion gases from two coals. Temperatures ranged from 440 to 3140 F and fuel-air ratios from 90 to 130 per cent of theoretical air. Results are pre-

sented in graphical and tabular form paying particular attention to sodium, sulfur, and chlorine compounds. A few of the many possible inferences relevant to fouling, corrosion, and air pollution are pointed out. Starting from the equilibrium-gas-composition results of Part 1, the regions of thermodynamic stability of various sodium and iron compounds are obtained in Part 2 as functions of temperature and fuel-air ratio. It is shown that purely thermodynamic considerations impose an upper temperature limit upon corrosion mechanisms involving complex iron sulfates. An explanation is advanced for the severe fouling tendency of high alkali coals.

A Study of Sulfur Reactions in Furnace Deposits . . 60—WA-183 . . . By M. Weintraub, S. Goldberg, and A. A. Orning, Mem. ASME, Bureau of Mines, U. S. Department of the Interior, Pittsburgh, Pa. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Power;** available to Oct. 1, 1961).

A study was made of absorption of sulfur from synthetic flue gas by coal ash. When fly ash was placed in a temperature gradient like that in a deposit on a boiler tube, maximum absorption was found in the coldest layer. When held at constant temperature, maximum absorption was found at 1100 F. The amount of absorption was highest for fly ash from furnaces in which serious deposit formation was observed. It was also highest for fly ash containing the highest content of sodium and potassium. The sulfur is probably absorbed as mixtures of normal sulfates, pyrosulfates, and such compounds as potassium-ferric trisulfate. A liquid phase of these compounds in contact with tube metal causes corrosion. The maximum sulfur absorption found at 1100 F coincided with a maximum at the same temperature that was observed for external tube-metal corrosion.

Corrosion of Superheaters and Reheaters of Pulverized-Coal-Fired Boilers, II . . 60—WA-180 . . . By Carl Cain, Jr., and Wharton Nelson, Combustion Engineering, Inc., Kreisinger Development Laboratory, Chattanooga, Tenn. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Power;** available to Oct. 1, 1961).

Studies of high-temperature fireside corrosion of reheater and superheater tubes in pulverized-coal-fired boilers are discussed. Factors affecting the temperature range and rate of corrosion by molten complex alkali sulfates are described. The influence of sulfides, produced by reaction of complex sulfates with tube metal, on corrosion rate is discussed. The similarity of coal-ash to oil-ash corrosion mechanism is brought out. Methods for distinguishing liquid phase from gas-phase corrosion on ferritic alloys are presented.

Slurry Spraying for the Control of Corrosion and Deposits in Oil-Fired Boilers . . 60—WA-284 . . . By W. F. Cantieri and R. E. Chappell, Mems. ASME, Diamond Power Specialty Corporation, Lancaster, Ohio. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The problems of corrosion and deposits in oil-fired boilers increase as the vanadium, sulfur, and sodium content of the oil increases. Many approaches have been tried to combat these problems, the most promising being the use of additives.

There are, basically, three methods of getting the additive into the boiler; namely, mix it with the fuel oil, inject it through the burners or ports in the furnace walls, or spray it on the tubes through soot blowers or other lances.

This paper summarizes investigations on the application of slurry-sprayed additives to oil-fired boiler tubes, which have been performed over the past five years in co-operation with the Florida Power & Light Company.

A brief history of additives and a description of the equipment and application considerations for slurry is also given.

Effect of Ammonia Injection on Corrosion in Air Preheaters . . 60—WA-255 . . . By R. Kato and B. E. Paris, Foster Wheeler Corporation, New York, N. Y. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Boiler-plant operators have long been aware that severe corrosion of economizers, air preheaters, and boiler casings occurs when metal temperatures drop below the water dew point. During load fluctuations and boiler shutdown, deposition of sulfurous acid, hydrochloric acid, and other corrosive substances takes place when water is condensed from the flue gas at its dew point, which may be from 100 to 130 F, depending upon the nature of the fuel and the boiler operating conditions.

In addition, modern boilers are also plagued by corrosion which occurs at temperatures above the water dew point. The consensus among researchers is that a small amount of SO_3 vapor in the flue gas causes condensation at temperatures higher than the water dew point, resulting in sulfuric-acid corrosion at temperatures ranging from 200 to 300 F.

Tests conducted in a pulverized-coal-fired boiler to investigate the effectiveness of ammonia injection in reducing this corrosion have shown that the injection of ammonia into the flue gases at 420 F virtually eliminated the corrosion at metal temperatures between 150 F and 420 F. It was further observed that no deposit build-up took place in the air preheater while ammonia was being injected over a period of 60 hr. To the best of the authors' knowledge, this is the first successful trial of ammonia injection in a large pulverized-coal-fired boiler.

New Developments for Handling the Fuel-Oil-Ash Corrosion Problem . . 60—WA-260 . . . By D. W. McDowell, Jr., The International Nickel Company, Inc., New York, N. Y.; and J. R. Mihalisin, The International Nickel Company, Inc., Bayonne, N. J. 1960 ASME Winter Annual Meeting paper (multilithograped; available to Oct. 1, 1961).

Since 1949 considerable attention has been focused, in the United States, on the high-temperature corrosion problem that the burning of residual fuel oils has presented to industry. This is particularly true in the Atlantic Coast states where large quantities of bunker C have been used for many types of industrial heating. The combustion products from these fuels include a considerable amount of ash containing vanadium pentoxide, sodium, and sulfur compounds. Such combustion products have a low fusion temperature and when liquid, exert a fluxing action on metal oxides with which they come in contact. Field tests have indicated that while this problem presents quite a challenge to the alloy-development metallurgist, new high chromium-high nickel alloys show promise in combating these very corrosive atmospheres.

Other approaches to the problem include oil treatment, additives, protective coatings, and design changes. These are considered in some detail with an appraisal of how successful these have been in solving the problem. Current laboratory work at The International Nickel Company, Inc., also is discussed.

Reactions of Magnesium With Inorganic Constituents of Heavy Fuel Oil and Characteristics of Compounds Formed . . 60—WA-278 . . . By W. D. Niles and H. R. Sanders, Esso Research and Engineering Company, Linden, N. J. 1960 ASME Winter Annual Meeting paper (multilithographed; to be published in **Trans. ASME—J. Engng. for Power;** available to Oct. 1, 1961).

High-temperature corrosion caused by trace quantities of metals together with sulfur is a continuing problem in heavy-fuel-oil operation, particularly in new high-temperature steam boilers and gas turbines.

The best key to an improved insight into these problems is perhaps a better understanding of the basic chemistry of

the sodium-vanadium-magnesium-sulfur systems involved. A study of the literature showed that considerable work has been done in this area. For example, sodium-vanadium reactions have been fairly well defined and the identification of some magnesium-vanadium compounds has been made. However, several important gaps in available knowledge were apparent. These included the physical characteristics of the compounds, the factors influencing the type of magnesium-vanadium compound which forms, and the reason why magnesium additives cause increased deposition under certain conditions.

To fill in these gaps, a research program was undertaken by Esso Research. This involved checking available literature data on the sodium-vanadium-sulfur system, doing new work on the magnesium-vanadium-sulfur system, and studying the physical behavior of the compounds formed.

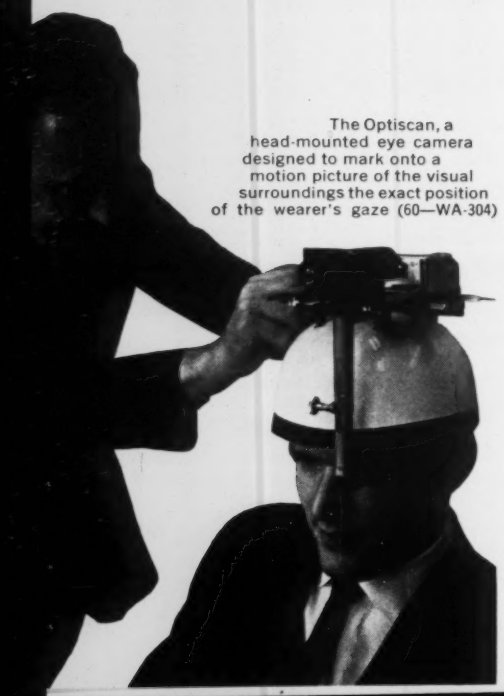
High-temperature reactions of magnesium with heavy-fuel-oil ash were studied in static reaction tests and the products formed were identified. The effect of SO_3 partial pressure on fuel-ash reactions and the corrosivity of the compounds formed were established. This work has enabled development of a systematic method of predicting deposit compositions and characteristics from a knowledge of fuel-ash composition and burner-operating conditions. Extensive comparisons are made between predicted compositions and actual analysis of deposits from commercial burner units.

Human Factors

Some Suggested Uses for the Optiscan—A Head-Mounted Eye Camera . . 60—WA-304 . . . By Norman H. Mackworth, Dunlap and Associates, Inc., Stamford, Conn. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The Optiscan, a new optical-eye camera, registers where someone is looking by marking the position of the line of sight onto a photographic image of the scene. An 8-mm movie camera is mounted on a helmet to record the general area of regard as this is selected by head and body movements. Somewhere on this movie record of the scene is also a bright spot of light; this additional record, termed the eye-marker, represents the specific position of the line of sight determined by the eye movements. This eye-marker is obtained from the corneal reflection by a periscope in front of one eye.

The possible uses of this technique encompass a wide range of problems—real-life as well as laboratory situations. In the area of engineering these are concerned with the design and general layout of information rooms and wall boards as well as with the design of individual displays for specific instruments. In consumer research they include the measurement of choice and the study of attention-getting devices. Medical applications deal with accident prevention, studies of drugs, and adverse environments as well as brain and eye diseases. Basic research is seen to take the form of studies in visual search and tracking as well as in reading and shape recognition. Much can be done also on problems arising during prolonged performance at exacting inspection tasks.



The Optiscan, a head-mounted eye camera designed to mark onto a motion picture of the visual surroundings the exact position of the wearer's gaze (60—WA-304)

The Human Eye as a Servo Control Mechanism . . 60—WA-281 . . By Carroll T. White, U. S. Navy Electronics Laboratory, San Diego, Calif. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The front of the eye is electrically positive in respect to the back of the eye. This potential difference, known as the corneo-retinal potential, has proved to be extremely useful in the study of various problems in vision.

The corneo-retinal potential has been utilized in the study of eye movements during reading and other visual tasks. This can be accomplished by placing electrodes next to the outer edge and above and below each eye. As the front of the eye approaches an electrode the site of that electrode will become increasingly positive electrically, while the opposite electrode will become increasingly negative. It has been found that by recording these d-c potential changes with electrodes placed as described it is possible to obtain reasonably accurate representations of the horizontal and vertical components of the eyes' movements.

The fact that the horizontal and vertical components of eye movements can be obtained in this manner has led to speculation that the eye might, in certain situations, be used as a control mechanism.

The author describes an attempt to control a servo-driven device in this way. The device is a gimbal-mounted light-beam projector, whose point of aim is controlled by two sets of servo-driven rack-and-pinion gears, one set for the horizontal and the other for the vertical component. It was designed for an entirely different purpose, but it can be controlled by feeding the potentials representing the X and Y-components of the eye movements, suitably amplified, into its servomotors.

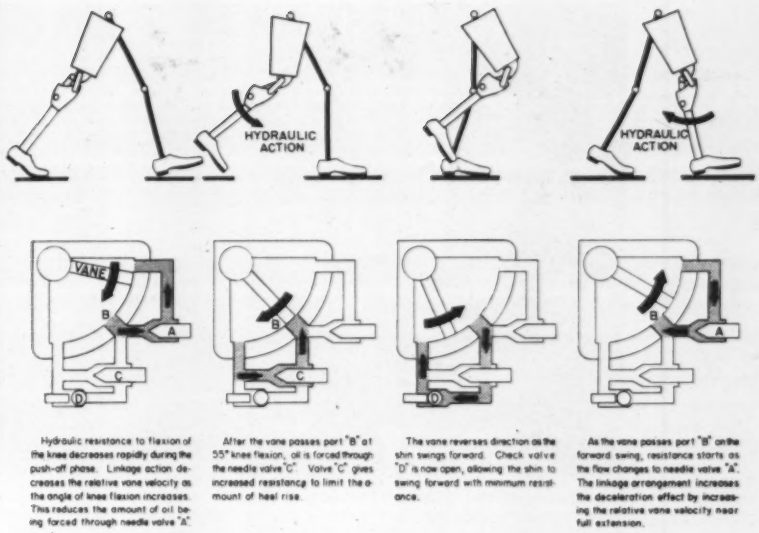
The Evolution of Locomotion: A Conjecture Into the Future of Vehicles . . 60—WA-303 . . . By M. G. Bekker, Land Locomotion Laboratory, Ordnance Tank-Automotive Command, Detroit, Mich. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

There seems to be a continuity of evolution of locomotion on Earth surface. It started with crawling and sliding of reptiles and ended with the rolling of man-made wheels. On this background, a wheel and the road appear to be the ultimate, although walking and running have not been surpassed in versatility, economy, and efficiency in off-the-road locomotion.

Whether it is necessary to imitate animal locomotion in automotive design has been a doubtful question, for roads. rails, and wheels are much easier to make, If, however, there were a need to construct a walking or running vehicle for operation on the moon's surface where no roads exist, then the problem might be of some interest.

Such a problem, however, would not be that of kinematics and dynamics of translation or straightforward mechanical engineering. It would be the problem of designing an incredibly complex system of feedbacks, controls, and equilibrators which would provide the sensing and controlling ability needed to maintain the stability of the vehicle at high speeds that running can produce.

For the moment, however, there is nothing better in sight in land locomotion beyond the wheel with all its



A complete artificial-limb assembly including the four-bar linkage and hydraulic vane damper. Diagram at **right** shows sequence of operation of hydraulic vane unit (60—WA-305).

Hydraulic resistance to flexion of the knee decreases rapidly during the push-off phase. Linkage action decreases the relative vane velocity as the angle of knee flexion increases. This reduces the amount of oil being forced through needle valve "A".

After the vane passes port "B" at 55° knee flexion, oil is forced through the needle valve "C". Valve "C" gives increased resistance to limit the amount of heel rise.

The vane reverses direction as the shin swings forward. Check valve "D" is now open, allowing the shin to swing forward with minimum resistance.

As the vane passes port "B" on the forward swing, resistance starts as the flow changes to needle valve "A". The linkage arrangement increases the deceleration effect by increasing the relative vane velocity near full extension.

variants produced by pneumatic tires and track-laying mechanisms. Spider-legged vehicles may be considered as fiction, for the present.

Experimental Cerebral Concussion. 60—WA-273 . . . By H. R. Lissner, Mem. ASME, Wayne State University, Detroit, Mich.; and E. S. Gurdjian, Wayne State University and The Grace Hospital, Detroit, Mich. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Experimental concussions were produced in anaesthetized dogs by various means. Blood pressure, pulse rate, and respiration were monitored and used to provide evidence of the degree of concussion produced. Accelerations of the head, intracranial pressures, and their time durations were recorded and an attempt was made to correlate these factors with the degree of concussion produced. Interpretation of the results obtained indicates that shear stress in the brain stem region of the brain causes cell damage and hemorrhages which are the direct cause of concussion.

The Center of Mass of Man . . 60—WA-306 . . . By Barry G. King, C. T. Patch, and Paul G. Shinkman, Operations Research Inc., Silver Spring, Md. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

While the position of man's center of mass (CM) changes as the various parts of the body are moved with respect to each other, it will lie within certain boundaries which can be considered to be the "center of mass envelope." It is the purpose of this paper to describe these maximum displacements of the CM from the CM of the human body in erect standing posture which result from maximum movements of the affected joints. The calculations for developing the envelope are based upon such data as are available in the literature.

This description is considered to be adequate for understanding motion and changes in motion of the body from forces directed through or outside the CM.

Biomechanical Design of a Lower-Extremity Prosthesis . . 60—WA-305 . . By Charles W. Radcliffe, Assoc. Mem. ASME, University of California, Berkeley, Calif. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

The design and development of an improved prosthesis for the above-knee amputee constitutes an unusual problem for the engineering designer. The prosthesis worn by an amputee is a specialized mechanism which becomes a part of all his daily activities—a true man-machine combination—and must provide unfailing performance under many different conditions. Its design must be based on biological and mechanical principles.

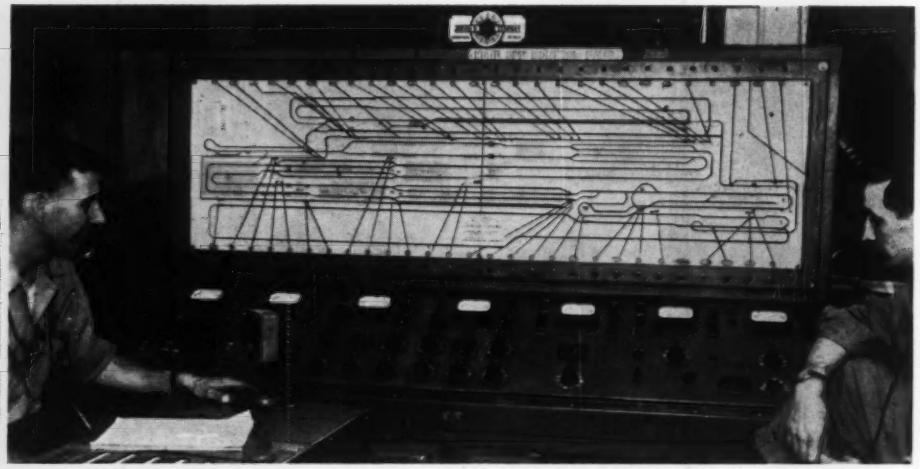
Criteria are established for the design of a prosthesis for above-knee amputees. Included is an analysis of factors which influence the stability of the prosthetic-knee mechanism against buckling; a comparison is made between designs based on passive-alignment stability and those based on active-voluntary control of knee stability by use of hip and stump musculature. A combination four-bar linkage and hydraulic-damper unit has been found to provide many functional advantages to above-knee amputees.

Materials Handling

Methods Engineering in Materials Handling . . 60—WA-99 . . . By J. C. Somers, Mem. ASME, Industrial Products Engineering Company, Long Island City, N. Y. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

A most difficult problem today is to provide adequate and flexible materials flow under conditions of unpredictable output-input quantities. Making the problem extremely complex are severe requirements in quality control, where error due to variance may prove of serious consequence at the point of use of the product. The significance of the role of the methods engineer is discussed with his work in determination of adequate flow techniques. His function can be devoted to enumerative studies to evaluate and correct a specific item or thing. It can alternatively be an analytical study involving a process analysis and a complete essential flow technique.

Where the work relates to analytical study, plant layout or work simplification or simulation, and in some cases mathematical modeling may be used; at the present state of science, as it is developing, these are the available tools. Their practicability in each case depends on the complications and difficulties of each project. Their value also depends on the skill of the engineer and his



A central monitoring panel for 40 conveyer drives in seven systems. Two of the systems have 10 synchronized conveyers each, plus auxiliary units. Each system has one master drive with speed controlled by a manual switch on the console. Lights around the map show any point of stoppage and distinguish between normal production and trouble stops (60—WA-223).

thinking with regard to research techniques available in the current, rapidly changing world of science, space, and research.

Materials Handling Transportation Fork Truck Versus Trailer Train . . 60—WA-101 . . . By Frederick C. Winter, Mem. ASME, Columbia University, New York, N. Y. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Two categories of materials-handling equipment are potential competitors of one another where materials are to be moved intermittently, over varying distances and over irregular routes. They are the industrial fork-lift truck employing a variety of attachments and the tractor-trailer train. Various authorities have published figures that range from 100 to 300 ft as a guide to the economic limit of fork-lift-truck materials transportation. Beyond this range they indicate that the transportation is in the province of the tractor-trailer train.

As a partial result of larger U.S. Department of Agriculture research projects conducted in several industries and based on an across-the-industry approach, additional data have become available for evaluating the application of these two media of materials transportation.

Research results are presented for the handling of both palletized and unpalletized materials by this equipment under comparable conditions.

Synchronization of Conveyer Drives . . 60—WA-223 . . . By Jervis C. Webb, Mem. ASME, Jervis B. Webb Company, Detroit, Mich. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Synchronization of conveyer drives is a means of continuous processing, amounting to controlled or self-regulated continuous flow of work from one conveyer or machine to another until the work is completed. This paper considers the synchronization of drives on independent conveyers, assuming that each conveyer has only one drive. The discussion is confined in this manner so as not to confuse the art of synchronizing drives between independent conveyers with the art of "balancing" which is synchronizing several drives on the same conveyer, a closely related problem.

Synchronizing normally requires consideration of two factors—speed and position. For proper synchronization of conveyers certain basic requirements must be met: (*a*) All load spaces on the conveyer must be equal. (*b*) Drives require a means for remote-control speed changing and brakes for uniform stopping. (*c*) Controls must provide interlocking so all conveyers will run and change speed together. (*d*) Controls must set the speed of individual conveyers to maintain position relationships, permit manual emergency operation, and provide signals to show malfunction or local stoppage. (*e*) The conveyer path and control should provide for positive transfer of carriers across gaps between independent conveyers.

Although all the methods of synchronization seem to be completely intertwined, for purposes of practical discussions they are broken down into three different categories: (*a*) Direct mechanical ties; (*b*) drives locked in step; (*c*) drives with feedback control.

Applied Mechanics

On the Stability of the Linearly Related Modes of Certain Nonlinear Two-Degree-of-Freedom Systems . . 60—WA-26 . . . By C. P. Atkinson, Mem. ASME, University of California, Berkeley, Calif. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

A method is presented for analyzing a pair of coupled nonlinear differential equations of the Duffing type in order to determine whether linearly related modal oscillations of the system are possible. The system has two masses—a coupling spring and two anchor springs. For the systems studied, the anchor springs are symmetric but the masses are not. The method requires the solution of a polynomial of fourth degree which reduces to a quadratic because of the symmetric springs. The roots are a function of the spring constants. When a particular set of spring constants is chosen, roots can be found which are then used to set the necessary mass ratio for linear modal oscillations. Limits on the ranges of spring-constant ratios for real roots and positive-mass ratios are given. A general stability analysis is presented.

Random Excitation of a System With Bilinear Hysteresis . . 60—WA-27 . . . By T. K. Caughey, California Institute of Technology, Pasadena, Calif. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Hysteresis may be due to the presence of Coulomb friction in the system, or it may be due to elastoplastic behavior of the material in the system. As an

example of hysteresis due to Coulomb friction, consider a steel-framed building with masonry walls. The masonry is held in place primarily by its own weight and the resulting frictional forces developed between the masonry blocks. If the building is caused to vibrate, both the masonry and the structural steel work contribute to the stiffness of the building. For small amplitudes of motion, the shearing forces in the masonry are insufficient to overcome the frictional forces, and the masonry contributes considerable shear rigidity to the building. As the amplitude of the motion is increased a point will be reached at which the shearing forces in the masonry exceed the frictional forces, and relative sliding will then occur. During this portion of the motion the shear rigidity of the building is that of the structural steel work; though the masonry no longer contributes to the rigidity of the structure, the relative sliding of the masonry blocks dissipates energy, thereby providing an additional source of damping. Such a system would exhibit bilinear hysteresis of the type shown.

An analysis is made of the response of a system with bilinear hysteresis to random excitation. It is shown that for moderately large inputs, the additional damping created by the bilinear hysteresis decreases the mean squared deflection compared with that for a linear system with the same viscous damping. However, for large inputs, the decrease in the stiffness of the system due to the bilinear hysteresis causes the mean squared deflection to increase over that for the equivalent linear system.

On the Compressibility Effects of the Lubricant for Two-Dimensional Slider Bearings . . 60—WA-29 . . . By K. T. Yen, Rensselaer Polytechnic Institute, Troy, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

An analytical study of the compressibility effects on the characteristics of two-dimensional slider bearings is made. By the variational method, it is shown that, for a given bearing length, no optimal film shape of the bearing can be found to yield a maximum total load. Analysis of the numerical results carried out for stepped films with a compressible lubricant under isothermal compression or expansion indicates that this anomaly is due to the nonlinear nature of the compressible problem. By considering a modified variational problem, it is further shown that stepped-film bearings with isothermal lubricant still yield the maximum total load for a given mass flow rate passing through the bearings, but the exact shape of the optimal stepped film is found to depend on the value of the maximum pressure.

Stresses and Deflections in an Elastically Restrained Circular Plate Under Hydrostatic Normal Pressure Over a Segment . . 60—WA-30 . . . By W. A. Bassali, University of Alexandria, Alexandria, Egypt; and N. O. M. Hanna, Ein Shams University, Cairo, Egypt. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Discussed is the application of complex variable analysis to establish exact expressions for the small deflections occurring in a thin isotropic circular plate subject to hydrostatic transverse pressure distributed over a segment of the plate. The general boundary conditions taken at the edge of the plate include those for the simply supported and rigidly clamped boundaries as particular cases. In the latter case the solution is obtained in a closed form.

Explicit formulas are given for the boundary values of the bending and twisting moments and shearing forces. Expressions are also developed for the corresponding values on the axis of symmetry. When the hydrostatic pressure extends over a half of the plate or over the entire plate, the problem is investigated in detail and numerical results are presented in the form of tables and graphs. The results obtained are of practical significance in connection with the design of cylindrical tanks and boilers.

Forced Oscillations of a Semi-Infinite Rod Exhibiting Weak Bilinear Hysteresis . . 60—WA-28 . . . By T. K. Caughey, California Institute of Technology, Pasadena, Calif. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Many physical systems exhibit hysteresis and frequently the hysteresis is nonlinear in nature. One simple example of nonlinear hysteresis is bilinear hysteresis. The author has analyzed the response of a single-degree-of-freedom bilinear hysteresic system to sinusoidal excitation and to random excitation. In this paper an analysis is made of the forced sinusoidal oscillations of a semi-infinite rod exhibiting weak bilinear hysteresis.

A Modification of the Coulomb-Mohr Theory of Fracture . . 60—WA-31 . . . By Burton Paul, Assoc. Mem. ASME, Technik, Inc., Garden City, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

The inability of the Coulomb-Mohr theory of fracture to explain the main features of compression, tension, and torsion tests on brittle materials is pointed out. It is shown that the introduction of suitably chosen tension cutoffs and "friction angles" removes this deficiency and leads to a satisfactory explanation of the fracture stresses and angles of fracture for these three simple tests. The modified Coulomb-Mohr theory is a three-parameter theory, but all three parameters in principle can be obtained from only two simple tests. It is shown that in the case of cast iron there is an extremely close relationship between cohesive resistance in shear and nominal ultimate strength in single or double shear. The modified theory fits the data of Coffin, Cornet, and Grassi on biaxial fracture of cast iron very well. The three-dimensional fracture surface is described and used to explain some apparently anomalous points in the experimental data. Finally, a hypothesis is advanced which explains the appearance of concavities in the yield locus for certain classes of materials.

The Effect of Shear and Normal Forces on the Fully Plastic Moment of a Beam of Rectangular Cross Section . . 60—WA-102 . . . By B. G. Neal, University College of Swansea, Swansea, Wales, G. B. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

The plastic methods of structural analysis for framed structures depend essentially on the plastic hinge concept. A plastic hinge cannot undergo any rotation until the bending moment reaches a value termed the fully plastic moment, but can undergo an indefinite amount of rotation while the bending moment remains constant at the fully plastic value. In many applications of the plastic methods, the fully plastic moment is treated as a constant for a member of a given cross section and material, but it is known that its value is affected by both axial force and shear force at the hinge section. In structural frames subjected to statical loading, the effect of shear force is usually small, and axial force only becomes important in heavily loaded columns. However, under conditions of dynamical loading, the applied loads may be considerably greater than those which would cause failure by plastic collapse under statical loading, so that shear and axial forces may become large enough to have a substantial effect on the value of the fully plastic moment.

Little attention has been paid to the reduction caused by normal and shear forces acting simultaneously. This problem is discussed with reference to a cantilever beam of rectangular cross section subjected to both shear and normal forces at the free end. Upper and lower

bounds to the collapse load are determined, and the results are presented in the form of interaction relations between the shear and normal forces and the bending moment at the clamped end of the cantilever at collapse.

Experiments on the Postbuckling Behavior of Square Plates Loaded in Edge Compression . . 60—WA-103 . . . By Noboru Yamaki, Institute of High Speed Mechanics, Tōhoku University, Sendai, Japan. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

The failing strength of a rectangular plate under edge compression can exceed appreciably the buckling strength when the thickness is sufficiently small in comparison with its other dimensions. Thus it is of practical importance to clarify the postbuckling behavior of the plate, and numerous researches, both theoretical and experimental, have been carried out. However, most of these studies seem to be confined to the case where the plate is simply supported along all the edges.

In a previous paper, "Postbuckling Behavior of Rectangular Plates With Small Initial Curvature Loaded in Edge Compression," the author investigated this problem theoretically under eight different boundary conditions and presented numerical solutions for square plates with and without initial deflection, assuming the Poisson's ratio as $1/3$. To compare with these results, experiments were conducted under four different boundary conditions by using aluminum square plates with a side length of 11.8 in. and thickness of 0.04 and 0.05 in. The test equipment and procedures are described briefly and then experimental results are presented and discussed in some detail.

It is found that the experimental results are in reasonable agreement with those theoretically predicted.

Adiabatic Analysis of Elastic, Centrally Pivoted, Sector, Thrust-Bearing Pads . . 60—WA-104 . . . By B. Sternlicht, Assoc. Mem. ASME, G. K. Carter, and E. B. Arwas, Assoc. Mem. ASME, General Electric Company, Schenectady, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Pivoted-pad thrust bearings present a special problem in thrust-bearing analysis. This is due to the fact that the pads of such bearings are generally supported on a finite number of "point" or "line" contacts. Thus, under heavy load, the pads deform due to the load and to the thermal gradients that are generated by the shear losses. Furthermore, the magnitudes of these deformations are often several times the minimum thickness of the fluid film on which the bearing operates.

This paper emphasizes the importance of temperature in thrust-bearing analysis. The analysis presented consists of simultaneous solution of the momentum, energy, and elasticity equations for centrally pivoted, sector-shaped, thrust-bearing pads. Elastic deformations due to the pressure distribution and thermal gradients are considered. Laminar and adiabatic conditions are assumed in the fluid film, and the lubricant is incompressible.

Torque and Cavitation Characteristics of Butterfly Valves . . 60—WA-105 . . . By Turgut Sarpkaya, University of Nebraska, Lincoln, Neb. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Valves are assemblies of one or more basic flow-restricting elements, and nearly all of these basic elements belong to one of the three main classes; namely, sliding, seating, and flow-dividing elements. Butterfly valves, which belong to both the second and third classes, are installed in pipes or penstocks and are normally used for either closure valves or for flow-rate control or governing.

The present study deals with hydrodynamic torque and cavitation inception of idealized two-dimensional and axially symmetrical butterfly valves. Theoretical results obtained for the two-dimensional case are compared with the ones obtained experimentally and by a relaxation technique. Based on the results of the two-dimensional case, an approximate solution is presented for the more general and practical case of three-dimensional butterfly valves. The results are in good agreement with the actual flow tests.

The detailed laboratory and theoretical investigations of butterfly valves described warranted the following conclusions:

1 The bulk characteristics of flows through two-dimensional and axially symmetrical butterfly valves are essentially the same.

2 The inception of cavitation can be predicted from comparative two-dimensional studies as a function of the geometry of the valve system and of the upstream and downstream conditions.

3 The torque to be provided for varies widely for various conditions but is nevertheless perfectly definite and subject to calculations when the controlling factors are known. For a free-discharge valve the maximum value of the torque coefficient is about 0.03, and occurs at about 20 deg from the full-open position. As a result of the theoretical and experimental data presented herein the moments to be expected for a butterfly valve in any setting and under any head can be calculated.

On the Response of Linear Systems to Time-Dependent, Multidimensional Loadings . . 60—WA-106 . . . By F. P. Beer, Mem. ASME, Lehigh University, Bethlehem, Pa. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

The concept of frequency response, which has long been used by communication engineers to predict the response of a linear system to a periodic, nonperiodic, or random input, is extended to the general case of a linear mechanical system subjected to a time-dependent, multidimensional loading. Various possible methods for determining the transfer function of a given system are examined. One method is given special attention; it is based on the cross correlation in space and time of the response of the given system to a multidimensional random load field with the response of another system to the same field.

On the Buckling of Circular Cylindrical Shells Under Pure Bending . . 60—WA-33 . . . By Paul Seide, Assoc. Mem. ASME, and V. I. Weingarten, Space Technology Laboratories, Inc., Los Angeles, Calif. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

For many years, the theoretical maximum bending stress that will cause buckling of a circular cylindrical shell has been commonly accepted as being equal to 1.3 times the compressive buckling stress. This factor having been accepted, experimental data for bending instability have been consciously analyzed in many cases to indicate an empirical reduction coefficient 1.3 times that for compression.

The stability of circular cylindrical shells under pure bending is investigated by means of Batdorf's modified Donnell's equation and the Galerkin method. The results of this investigation have shown that, contrary to the commonly accepted value, the maximum critical bending stress is for all practical purposes equal to the critical compressive stress.

The Bending, Buckling, and Flexural Vibration of Simply Supported Polygonal Plates by Point-Matching . . 60—WA-38 . . . By H. D. Conway, Cornell University, Ithaca, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

The bending by uniform lateral loading, buckling by two-dimensional hydrostatic pressure, and the flexural vibrations of simply supported polygonal plates are investigated. The method of meeting the boundary conditions at discrete

points, together with the Marcus membrane analog is found to be very advantageous. Numerical examples include the calculation of the deflections and moments, and buckling loads of triangular square, and hexagonal plates. A special technique is then given, whereby the boundary conditions are exactly satisfied along one edge, and an example of the buckling of an isosceles, right-angled triangle plate is analyzed. Finally, the frequency equation for the flexural vibrations of simply supported polygonal plates is shown to be the same as that for buckling under hydrostatic pressure, and numerical results can be written by analogy. All numerical results agree well with the exact solutions, where the latter are known.

On Transient Thermal Stresses in Viscoelastic Materials With Temperature-Dependent Properties . . 60—WA-124 . . . By Rokuro Muki and Eli Sternberg, Assoc. Mem. ASME, Brown University, Providence, R. I. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to Oct. 1, 1961).

This paper deals with the quasi-static analysis of transient thermal stresses in the linear theory of viscoelastic solids with temperature-dependent properties. The underlying constitutive law rests on the temperature-time equivalence hypothesis.

Following an exposition of the theoretical framework exact solutions to two specific problems are deduced: The first concerns the thermal stresses in a slab of infinite extent, generated by a temperature field that depends arbitrarily on the thickness co-ordinate and time; the second application concerns the stresses produced in a sphere by an arbitrary time-dependent radially symmetric temperature distribution. The numerical illustrations of the results obtained include a quantitative study based on actual test data for a polymethyl methacrylate.

On the Burmester Points of a Plane . . 60—WA-125 . . . By Ferdinand Freudenstein, Assoc. Mem. ASME, Columbia University, New York, N. Y.; and George N. Sandor, Mem. ASME, Time Inc., Springdale Laboratories Division, Springdale, Conn. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to Oct. 1, 1961).

The paper is divided into three parts concerned with the Burmester points associated with five distinct positions of a plane. In the first part, "Theory," an equation is derived for the location of the Burmester points; algebraic and geometric properties of these points are deduced and special cases considered. An automatic digital-computer program is described in the second part, "Computation," using a parametric form of the equation for the Burmester points. In the third part, "Application," the analytical form of Burmester theory is applied to the solution of a variety of problems in plane kinematic synthesis in one uniform manner.

The methods presented are suited also for use with error-minimization techniques described elsewhere and thus represent a step toward the unification of kinematic synthesis techniques.

Transient Capillary Rise in Reduced and Zero-Gravity Fields . . 60—WA-201 . . . By Robert Siegel, Assoc. Mem. ASME, Lewis Research Center, NASA, Cleveland, Ohio. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to Oct. 1, 1961).

When the end of a tube or piece of porous material is immersed in liquid that wets the surface, capillary action will cause the liquid to penetrate into the tube or material. An understanding of the dynamics of this penetration process arising from the surface-tension force is of importance, for example, in soil mechanics, the wetting of textiles, and in lubrication.

The present interest in capillary motion arose in connection with liquid systems for use in space-flight applications. In a satellite or space vehicle an environment may be encountered with a very low or zero-gravity field. In this instance the weight of the liquid becomes very small, and if the fluid has a free surface, the surface tension may have a significant effect in moving the liquid about.

Experimental information is given on the transient "capillary" rise of water into vertical tubes subjected to reduced and zero-gravity fields. The tubes ranged in internal diameter from 0.075 to 1.295 in. The response in a low-gravity environment is of interest in studying the behavior of liquid systems for space vehicles. An approximate analysis is presented to aid in the interpretation of the data and predict the transient rise. Photographs illustrate the behavior in short tubes where the water is able to move beyond the top of the tube during part of the zero-gravity period.

Transient Thermal Stresses in a Circular Cylinder . . 60—WA-123 . . . By C. K. Youngdahl and Eli Sternberg, Assoc. Mem. ASME, Brown University, Providence, R. I. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to Oct. 1, 1961).

The present investigation concerns the transient temperature distribution, as well as the accompanying time-dependent thermal stresses and deformations, which arise in a circular elastic shaft of infinite length if a finite band of its surface, between two cross sections, is exposed to an instantaneous uniform change in temperature. The entire shaft is assumed to be at a constant initial temperature and—without loss in generality—is considered to be free from loading. While the requirement that the surface temperature be a step-function of time is physically unrealistic, the corresponding solution may, by means of the usual convolution integral, be adapted to an arbitrary time dependence of the temperature within the heated (or cooled) surface band. The solution given here is therefore relevant to the study of thermal stresses produced in a rotating shaft as a consequence of bearing friction.

The foregoing problem is approached on the basis of classical linear thermoelasticity theory. In particular, the material is supposed to be homogeneous and isotropic with respect to both its thermal and mechanical response, and all physical properties are regarded to be independent of temperature. Furthermore, the treatment is quasi-static in the conventional sense that inertia effects are neglected along with the influence of thermoelastic coupling.

The solution obtained is exact within the underlying theoretical framework.

On the Dynamic Behavior of a Frank-Read Source . . 60—WA-204 . . . By J. D. Campbell, Oxford University, Oxford, England; J. A. Simmons and J. E. Dorn, University of California, Berkeley, Calif. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to Oct. 1, 1961).

The propagation of plastic waves in crystalline solids is determined by the behavior of dislocations. Following application of stress there will be a period of acceleration of dislocations since dislocations possess a small effective mass. After a very short time interval dislocation interaction will be so great that the strain rate will level off and the material will work-harden. Finally, the solid will come to a quasi-static condition in which the plastic strain will be almost constant for a constant stress.

The equation of motion for a curved dislocation moving at high velocities in a slip plane is solved for a dislocation half-mill. It is found that the angular velocity of a dislocation half-mill about the spinning point is constant for constant stress. The solution is applied to a Frank-Read source to give the shape of the nucleating source and the time of activation. For Al, the time of nucleation of a Frank-Read source is about 5×10^{-10} sec when the stress on the source is $10^{-4}G$.

Investigation of Flat-Plate Hypersonic, Turbulent Boundary Layers With Heat Transfer . . 60—WA-205 . . . By Eva M. Winkler, U.S. Naval Ordnance Laboratory, Silver Spring, Md. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Naturally turbulent boundary layers on a cooled flat plate have been investigated at several distances from the leading edge of the plate at a Mach number of 5.2 for three rates of steady-state heat transfer to the surface. Measurements of pitot and static pressures and of total and wall temperatures made it possible to compute velocity profiles, static-temperature profiles, and boundary-layer parameters without resorting to assumptions.

The data demonstrate that the Reynolds analogy between skin friction and heat transfer is valid for all conditions of the present experiments. With increasing rate of heat transfer to the surface, the skin-friction coefficient was found to decrease, a phenomenon opposite to that predicted by theories and empirical relations. On the basis of the present data and other published results of compressible and incompressible turbulent boundary-layer skin friction, a simple relation was devised that describes closely the variation of the skin-friction coefficient with Mach number, heat-transfer rate, and momentum-thickness Reynolds number.

The Elastic Plane With a Circular Insert, Loaded by a Radial Force . . 60—WA-202 . . . By J. Dundurs, Assoc. Mem. ASME, and M. Hetényi, Mem. ASME, Northwestern University, Evanston, Ill. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

The problem treated is that of a plate of unlimited extent containing a circular insert and subjected to a concentrated radial force in the plane of the plate. The elastic properties of the insert are different from those of the plate, and a perfect bond is assumed between the two materials. The solution is exact within the classical theory of elasticity, and is in a closed form in terms of elementary functions. Explicit formulas are given for the components of stress in Cartesian co-ordinates, and also in polar co-ordinates at the circumference of the insert.

The Laminar Boundary Layer on a Hot Cylinder Fixed in a Fluctuating Stream . . 60—WA-203 . . . By R. J. Gribben, Massachusetts Institute of Technology, Cambridge, Mass. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

In this paper two-dimensional oscillatory flow past a fixed body with a steady mean component of velocity is considered, and solutions of the boundary-layer equations for low-speed, compressible flow are found by using Pohlhausen's approximate method of integration.

The general theory is developed starting from the boundary-layer equations for low-speed compressible flow. The Karman-Pohlhausen method of integration across the boundary layer is then employed to solve the equations with quartic profiles assumed for the velocity and temperature.

The first example considered is the simple case of fluctuating flow over a flat plate for which some exact solutions are known. The method is then applied to a further relatively simple special case, which concerns the flow over a circular cylinder.

An Exploratory Study of Three-Dimensional Photothermoelasticity . . 60—WA-49 . . . By Herbert Tramposch, Mem. ASME, International Business Machines Corporation, Poughkeepsie, N. Y.; and George Gerard, Mem. ASME, New York University, New York, N. Y. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

A sandwich technique which utilizes an embedded polariscope consisting of two sheets of polarizing material cemented within a plastic model was evaluated for application to three-dimensional photothermoelasticity. The evaluation included strength tests of cemented joints, photoelastic tests of simple bending models and a sphere, all under mechanical loading. The technique proved to be rather simple to apply particularly since the resulting fringe patterns are readily interpreted. The sandwich technique was then applied to thermal-stress problems associated with a thick-walled cylinder under steady-state conditions. The experimental results correlated well with theory. The results obtained indicate the general applicability of the sandwich technique to three-dimensional stress problems generated by mechanical or thermal loads. It is noted that since other experimental thermal-stress-analysis methods are not highly developed, photothermoelasticity would seem to be particularly useful.

On the Bending of Circular Cylindrical Shells by Equal and Equally Spaced End Radial Shear Forces and Moments . . 60—WA-32 . . . By Paul Seide, Assoc. Mem. ASME, Space Technology Laboratories, Inc., Los Angeles, Calif. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

In the analysis of discontinuity stresses in structures connected by rivets or bolts, it is customary to consider the bolt loads to be smeared out uniformly and to assume a state of axisymmetric deformation in the cylinder. The present investigation seeks to determine the limits of validity of these assumptions.

A cylinder subjected to equal and equally spaced end radial shear forces and moments is analyzed by means of Donnell's equations to determine the variation of radial deflections and slopes with number of loads and the radius-thickness ratio of the cylinder. Computations are carried out for concentrated loads and for loads that are distributed uniformly over equal and equally spaced angular segments. It is found that large nonuniform bending effects are obtained for combinations of number of loads, radius-thickness ratio, and circumferential load coverage for which uniform loading approximation might ordinarily be expected to be adequate.

An Improved Integral Procedure for Compressible Laminar Boundary-Layer Analysis . . 60—WA-24 . . . By Kwang-Tzu Yang, Assoc. Mem. ASME, University of Notre Dame, Notre Dame, Ind. 1960 ASME Winter Annual Meeting paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to Oct. 1, 1961).

Like any other approximate method solution, the integral procedure in laminar boundary-layer analysis has definite shortcomings, among which the arbitrary choice of profiles and boundary conditions to be satisfied is a good example. More important is the fact that oftentimes using more complex profiles, such as polynomials of higher order, exponential functions, or profiles derived from exact similarity solutions, does not necessarily yield more accurate quantitative results.

Therefore in a new analysis, the accuracy of using the integral procedure is never too well assured. Furthermore, this accuracy becomes extremely critical in the important boundary-layer stability analysis, where the first and second derivatives of the velocity profile and first derivatives of the temperature profile must be known accurately. Thus any fundamental improvement of the integral procedure capable of eliminating most of these uncertainties and providing a much higher degree of accuracy, as well as retaining essentially the same simplicity of the original procedure, would be highly desirable.

The purpose of this paper is to present such a fundamental improvement so that from now on the integral procedure may be used with greater confidence. It is shown, by means of comparisons with exact solutions covering cases of favorable, zero, and adverse pressure gradients, and of constant and variable surface temperatures with and without heat transfer, that in all cases very significant improvements in the calculated results are attained.

Process Industries

Characterization of Industrial Fabric Filters..60—WA-336... By George William Walsh and Paul W. Spaite, U. S. Department of Health, Education, and Welfare, Cincinnati, Ohio. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Filtration within multicompartmented fabric filter installations tends to proceed according to definite patterns, knowledge of which will contribute greatly to the solution of many problems which can arise in actual operation.

The systematic nonuniformities inherent in multicompartmented baghouse operation are explored and the over-all performance is analyzed in relation to the characteristics of the individual compartments. Those properties of an operating unit that can be used to characterize the installation are delineated, and a methodology developed whereby critical values of these properties may be calculated from easily obtainable field measurements. The critical characteristics are defined as the residual filter drag of a compartment, the terminal filter drag of a compartment, and the residual velocity. The utility of these to determine the cause of difficulties is discussed.

Boiler Feedwater Studies

The Relation Between Boiler Cleanliness and Feedwater . . 60—WA-216 . . . By Frank Urbane Neat, Baltimore Gas and Electric Company, Baltimore, Md. 1960 ASME Winter Annual Meeting paper (multilithographed; available to Oct. 1, 1961).

Not too many years ago, it was found that the pH of a boiler water need not be above 10.0 to achieve long hours of trouble-free operation. At that time, a few operators were delivering water to the boilers as nearly free of salts as was possible. These boilers operating with boiler water pH of from 8.0 to 9.5 were as subject to trouble as those operating at the optimum range of 10.3 to 11.5. Later, with the advent of boiler pressures above 1800 psi, and once-through boilers of the Benson type, operation with zero solids in the boiler water became a necessity.

To keep the boiler water free of solids, it is necessary that corrosion of the feedwater system be reduced to as near zero as is possible. A practical limit has been reached, by the application of ammonia and/or amines to the feedwater, in view of the fact that dissolved oxygen is present in all systems and the systems contain both copper alloys and steel. Further reduction in feedwater-system corrosion can be gained only by eliminating one or the other. As the boiler must be made of steel, copper becomes the victim of progress and it must be eliminated from the steam-water cycles, especially where the boiler pressure is above 1800 psi.

ASME TRANSACTIONS

Journal of Engineering for Power

The April, 1961, issue of the Transactions of the ASME—*Journal of Engineering for Power* (available at $1.50 per copy to ASME Members, $3 to nonmembers) contains the following:

The Critical and Two-Phase Flow of Steam, by W. G. Steltz. (59—A-223)

Cooling Tower Fan Performance, by G. W. Forman and N. W. Kelly. (59—SA-17)

A Fluid Mechanics Approach to the Labyrinth Seal Leakage Problem, by Geza Vermes. (60—GTP-12)

Natural Convection Flow in Liquid-Metal Mobile-Fuel Nuclear Reactors, by F. G. Hammitt and E. M. Brower.

Selection of the Hydraulic Turbines for the Mammoth Pool Project, by H. E. Burrier. (60—Hyd-10)

Reduction of Turbine Runner Vibration and Noise, by F. C. Taylor. (60—Hyd-4)

Experiences With Hydraulic Prime Mover Controls, by F. R. Schleif and L. M. Johnstone. (60—Hyd-9)

Effects of Brine Dispersion in the Allen Salt-Velocity Method, by L. J. Hooper. (60—WA-138)

Supercharging of a Large Two-Cycle, Loop-Scavenged Diesel Engine, by A. J. Henriksen. (60—WA-185)

Diagram for Conversion of Diesel Engine Outputs for Changed Atmospheric Conditions, by Soren Hansen. (60—WA-162)

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COMMENTS ON PAPERS

Condensing Water—How Does It Affect the River?

Comment by J. F. Brittain[1]

THIS author's paper[2] has brought to the front a subject that is becoming more critical every day. Since river sites for steam plants are becoming more difficult to obtain, not only because of the fact that many of the best of them already have been developed, but also due to the fact that growing demands for power are necessitating ever increasing size of plants with heat rejections to the circulating water of magnitudes almost undreamed of a few years ago. It takes a really large river to dissipate comfortably 5000×10^6 Btu per hour from a plant on the order of 1000 megawatts, and yet this must be done wherever possible if we are to use our streams to full advantage while meeting demands for more and more power.

How can we best use our streams for the common good? Too little data have been taken at or near existing plants to reach any conclusive results as to the over-all or specific effects upon the other uses of the rivers. We know that the use of a small portion of the total flow of a stream at any given time results in apparently negligible effects because the heat is either taken care of by dilution as suggested or by transfer to the atmosphere but, as the plant is expanded and the effects become noticeable, where is the optimum point of use from the over-all point of view?

Our organization and clients have been conscious of the pollution problem, not only due to heat from steam stations, but also from the effects that low intakes, taking water from the deep strata of reservoirs at hydroplants, may have upon oxygen content of water discharged from the hydrounits. Studies were made on the Roanoke River and, in order to avoid discharging water at the Roanoke Rapids plant that had come through the reservoir as a density current low in dissolved oxygen, submerged weirs were installed at the intakes to skim the aerated surface water into the turbines. It is to be hoped that the governmental agencies involved in these studies will soon make them public.

In another instance, where a large headwater reservoir releases cool water of good quality all summer, it has been possible to design a steam-station cooling system with an intake close to the bottom of a downstream reservoir so that, by taking full advantage of the density current flow, it is expected that the maximum temperature of the heated water from the condensers will be tolerable to game fish downstream.

We know that public agencies have been aware of the problem and have a desire to benefit the whole public. It is not only desirable but urgent that these agencies release data and findings for the benefit of the public and the engineering profession.

The Martins Creek investigation is an excellent example of what can be done in analyzing the effects of thermal pollution. Similar studies on other rivers, as well as on natural lakes and ponds used for the dissipation of heat, should be publicized. A serious effort should be made to collect and analyze data relating to forced cooling and thermal pollution in order to improve the basis for predicting the effects of thermal loads.

Comment by Lewis W. Cadwallader[3]

This paper is a timely and important contribution to a problem which is of growing concern to the utility industry.

The large increases in population, the tremendous industrial expansion, the rapidly increasing use of water by agriculture, and the rising per capita consumption of water have developed a widespread awareness of the importance of our water resources to our national economy.

This awareness has resulted in the development of resistance in many areas to the location of additional industrial facilities on its water resources due to fear of water-pollution problems. Many states have adopted water-pollution-control laws for the purpose of protecting the water of the state from industrial and other pollution. These laws are usually administered by boards or commissions appointed by the state and normally require an industry or other creator of waste to obtain a permit prior to discharging waste into any river or stream within the boundaries of the state. Some states have placed a limitation on the maximum temperature of the water which can be discharged into its rivers and streams and other states are considering the enactment of similar legislation. For instance, one Eastern state specifies that the temperature in the stream must not exceed 100 F within 50 feet from the waste outlet. Obviously, with many streams reaching a natural summertime water temperature of 85 F or above, this is a most difficult regulation for utilities to meet without occasional violation for short periods of time. However, such temperature restrictions are largely empirical as there is not sufficient scientific information available at the present time to definitely indicate what temperature restrictions should be imposed. Furthermore, it is entirely probable that no single temperature restriction could be properly applied in all cases due to the widely varying nature of rivers, streams, and lakes.

As a matter of practical application, rivers and streams are most susceptible to thermal or heat pollution during the summertime. In the winter, when water temperatures are relatively low, it is entirely possible and even probable that addition of heat has a beneficial effect on rivers and streams. However, in the summertime, low river flow occurring

[1] Hydraulic engineer, Stone & Webster Engineering Corporation, Boston, Mass.

[2] Melvin D. Engle, "Condensing Water—How Does It Affect the River," MECHANICAL ENGINEERING, vol. 83, January, 1961, pp. 34–38.

[3] Vice-president and mechanical engineer, Potomac Electric Power Company, Washington, D. C. Mem. ASME.

simultaneously with high natural water temperatures aggravate all types of water pollution. Hence it is during the summer months that the pollution problem is most critical and it is during these periods that power plants are most likely to aggravate river conditions.

Because of this situation, it appears important that power-plant design engineers study the design of new condensing equipment with particular attention to temperature rise of the water passing through the condenser. Where availability of water is no problem, single pass condensers can often be used to advantage. When cooling water supply is limited, careful study will indicate the most desirable compromise between temperature rise and water flow through the condenser.

In 1960 the Edison Electric Institute submitted to the Senate Select Committee of the U. S. Congress a carefully prepared report on the future of the electric-power industry in relation to water resources. EEI's report indicates that the investor-owned utilities circulated through their steam-plant condensers, in 1959, approximately 23,500 billion gallons of river, lake, and sea water and predicts that this requirement will become 86,000 billion gallons annually in 1980—an increase of almost 300 per cent. EEI predicts that, in the same period of time, the total water circulated through cooling towers will increase from 2750 billion gallons in 1959 to 15,500 billion gallons in 1980—an increase of almost 500 per cent. This reflects an increased use of cooling towers for power generation. Also of interest is EEI's estimate indicating that the use of artificial cooling reservoirs and ponds will increase by about 800 per cent by 1980. This all adds up to a tremendous amount of heat which must be dissipated in the production of electricity and it is the dissipation of this heat which is becoming a major concern of state water-pollution-control boards, fish and wildlife associations, U. S. Public Health Service, and the United States Congress.

Rivers and streams are generally capable of dissipating tremendous quantities of heat in relatively short distances. However, the effect of the higher temperature discharge water from plant condensers must be evaluated by experts for each plant location and for each river or stream as there are many variables to be considered. This appraisal of a plant's effect is far from an exact science and this writer would urge the utilities to make use of the best talent available in determining new plant locations. Temperature elevation of the waters of this country is becoming an important consideration in the granting of water-use permits to electric utilities and to industry.

Comment by T. S. Fetter, Jr.[4]

As the author of this paper[2] has so aptly expressed it, "Little substantiated information is to be found" in this area "and that which is available is insufficient to permit reliable conclusions." He and his company are to be congratulated for taking a major step forward to provide reliable field data regarding the effects of thermal discharges.

The data that have been collected relative to the aquatic plant and animal life, chemistry of the river, and sport fishing gives a true indication of the effect of the condensing water for this location. However, as the author states, "Local conditions govern the aquatic effects resulting from the discharge of the condensing water from a power plant to a river. Until more complete information is obtained, each case should receive individual study and treatment."

A few states have promulgated regulations to control heated discharges and several others are considering regulations. As would be expected, these regulations differ greatly as the water resources and river conditions vary from locality to locality and from state to state and as the agency or department of the government assuming control varies from state to state. This study by Pennsylvania Power and Light Company at Martins Creek and other similar but small scale studies all point up the fact that considerable, long-term research on the effects of heated discharges on the aquatic life and other aspects of a river is needed before workable regulations can be drawn up.

As needs grow, all uses of the streams including water supply, sewage disposal, recreation, and industry become increasingly dependent on the rivers. It is, therefore, important that these groups, together with the regulatory bodies, undertake research which will provide answers for our future use of this resource. Only in this way can we arrive at reasonable regulation.

Comment by Richard D. Hoak[5]

Some rather alarming statements have been made about the present and future results of discharging heated water to natural streams. It has been predicted that the growth of industry, especially of thermoelectric power generation, will raise the temperature of many streams to levels that will destroy aquatic life. As the author of this paper[2] has pointed out, however, there is little reliable information upon which to base sound conclusions. Data on temperatures lethal to fish have been obtained for the most part from laboratory studies, but these findings do not necessarily bear any close relationship to conditions in natural streams. The investigation on the Delaware River is therefore an important contribution to our understanding of the actual effects of heated water.

Various reasons have been cited for controlling steam temperatures by regulating the discharge of hot water, but the dominant concern is preservation of fish life. Heat can affect fish in several ways. Fish are killed by temperatures above some maximum, depending upon the species. While fish can survive temperatures up to their lethal maximum, it is claimed that they will not propagate above some lower temperature; for warm-water fish this is reported to be about 80 F. The toxicity of various substances in streams may increase with a rise in temperature; exact information on this phenomenon is rather meager. But the most important effect of heat is claimed to be its relationship to the concentration of dissolved oxygen in streams.

Dissolved oxygen is vital to fish, but it is also essential to micro-organisms in their aerobic assimilation of organic matter. The number of micro-organisms in a stream is proportional to the supply of food, i.e., dissolved and suspended organic material. These organisms, eaten by fish, need oxygen to live. Thus there is competition for the available oxygen between the fish and their food supply. But the concentration of oxygen is not as critical for bacteria as for fish, and, as organic pollution increases, the dissolved oxygen may become insufficient for fish to survive.

Oxygen is dissolved in water from the surrounding air and as a result of the photosynthetic activity of aquatic plants. Photosynthesis is usually the more important source of dissolved oxygen, particularly in deep and sluggish streams. But photosynthesis ceases at night, whereas the demand for oxygen by the stream biota continues unabated. It might therefore be expected that the concentration of dissolved oxygen would fall at night below the level at which fish can live. Unfortunately, information about dissolved oxygen concentrations after dark is somewhat limited because it requires an extra effort to get the data.

Samples from four large and three small streams in western Pennsylvania were analyzed in the field for dissolved oxygen

[4] Assistant to the President, Philadelphia Electric Company, Philadelphia, Pa. Mem. ASME.

[5] Senior Fellow, Water Resources, Mellon Institute, Pittsburgh, Pa.

on a 24-hour basis by Mellon Institute personnel during the summer of 1960. Concentrations ranged from 6.90 to 11.85 ppm, or 67 or 130 per cent of saturation. The lowest values, which occurred at night, were well above the 5 ppm aquatic biologists claim is essential for a healthy fish population. The streams studied were supposed to carry moderate to heavy loads of pollution, and it was anticipated that oxygen levels would fall to rather low values at night. The concentration of dissolved oxygen was related directly to the chlorophyll (the photosynthetic agent) content of the water and inversely to the bacterial population. Significantly, dissolved oxygen concentrations were greatest during the daytime when temperatures were highest. These findings apply only to particular stretches of specific streams, but they indicate that concern over low concentration of oxygen at night may be somewhat exaggerated.

The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission has concluded that 93 F is the maximum allowable summer temperature for streams that are expected to support a harvestable fish crop. The fact that F. J. Trembley, director, Lehigh University Institute of Research, has found a vigorous fish population in the lagoon where temperatures are much higher than 93 F points to the need for more field study on other streams. The temperature at which fish thrive in nature should be the criterion, rather than a value determined under laboratory conditions that may not simulate a natural environment.

The temperature of surface water in southern states is normally higher than in the North. This suggests that the effects of heated water on fish would be more severe because stream temperatures could be more easily raised above the lethal limit. Officials of health departments in southeastern and southern states have stated that heated waste water is not now a problem, although it is conceded that it might become one in the future. Fishermen like heated discharges in the South, just as they do along the Delaware, because it greatly improves wintertime fishing. This has been true for many years, and there is no indication of any diminution in the fish population. Perhaps this results from acclimatization, but fish also can become acclimated to warm water in the North.

It is to be hoped that surveys like Dr. Trembley's will be made on other streams. If other aquatic environments yielded similar results, there would be a basis for extrapolating the information to relatively analogous situations on streams that had not been studied in such detail. Water uses are so diverse that stream-control regulations cannot be uniform except in principle. Field studies are essential for establishing pollution controls that will serve the best public interest.

Comment by F. F. Mautz[6]

One of the most important considerations in selecting a thermal power-plant site is an adequate condensing water supply. Good sites from the standpoint of condensing water and over-all power-plant economics are relatively scarce, since they are limited to natural waterways, lakes, bays, or ocean areas. Although condensing water is returned to its original source in essentially the same quantity and chemical composition, it has heat transferred to it in the condenser. It is this added heat and resulting temperature increase in the discharged condenser cooling water which is being considered as possibly detrimental to aquatic life in some areas today.

Some years ago the Pacific Gas and Electric Company was confronted with the effect of the condenser cooling water at its Contra Costa Power Plant on fish life in the area. Since the plant was located in a spawning area, one of the questions which had to be answered was the effect on smaller fish in passing through the condenser cooling system. Extensive experiments were conducted at the plant site to determine the maximum temperature rise that smaller bass and salmon were able to withstand, and total temperature tolerance for both species. The experiments were conducted on the two species of fish in a test flume and later in an actual operating condenser. Striped bass and salmon, subjected to sudden water temperature rise, were found able to withstand a higher differential range than was originally believed. Yearling bass withstood a temperature rise of 16 F and a maximum temperature tolerance of about 90 F with a survival of approximately 90 per cent. Yearling salmon survived a temperature rise of 25 F without loss of life and their maximum temperature tolerance was about 83 F. Test flume experiments on bass of 3 in. to 6 in. in length indicate that they had a greater ability to withstand temperature rise than the smaller fish, probably because they are less subject to shock. The results of these experiments indicated that small striped bass and king salmon could pass through the plant with a high survival rate. The findings of this fish preservation study were reported in the State of California Department of Fish and Game Fish Bulletin No. 92 entitled "Studies on Fish Preservation at the Contra Costa Steam Plant of the Pacific Gas and Electric Company."

Aside from the results of the test described, it has been of interest to note that at all of our thermal power stations fishermen seek out the outfall area in which to do their fishing. Results also indicate that fishing is generally better in these warmer waters than elsewhere in the area. To date there have been no incidents of fish kills due to temperature of circulating water systems.

The author of this paper[2] describes temperature effects on the river from the discharge of the Martins Creek Electric Station and notes that the discharged warm water from the station lies on the surface of the river and does not affect the river water more than 2 ft 6 in. below the surface. Experiments at thermal stations on our own system have yielded similar findings. In fact, it appears that the warm discharged water moves as a shallow body or stream within the larger body of water and has reasonably well-defined limits—with temperature rapidly decreasing to that of the main body of water into which it is discharged. This is most clearly demonstrated by the use of water dyes placed in the discharge, which then give a visual picture of the discharge flow. The boundaries of the discharged warmer water flow are clearly defined and the mode and rate of dissipation into the surrounding body can readily be observed.

From observations and tests of operating systems it is difficult to see how discharging of warmer water into a river, bay, or ocean can adversely affect marine life. On the contrary, it appears that some actual benefits accrue from the discharge of warm waters, particularly in the improved fishing in the vicinity of the outfall. The over-all temperature effects on the body of water into which the discharge is made are limited since the temperature of the discharged water is rapidly decreased to that of the body into which it is discharged.

Experience leads one to concur with the author that insufficient substantiated information has been collected to date on the effects on marine life of discharge of condensing water into rivers, bays, lakes, or the ocean. Until more complete information is available each questionable area should be analyzed and studied individually, taking into account all the influencing factors such as relative quantities of discharged and receiving waters, temperatures, stream flow or tidal pat-

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terns, type of marine life affected, and their known temperature tolerances.

Comment by Sheppard T. Powell[7]

The author has presented an interesting paper[2] on a subject of growing importance to the power industry as well as others. There has been a recent flurry of activity among water-pollution control agencies to adopt control standards for the discharge of heated wastes to our rivers and lakes. Development of responsible and equitable control measures will require realistic and comprehensive investigations such as the one the author reported.

The increased concern of water-pollution control agencies and industry regarding heated discharges to our watercourses is not without justification. Already there are local areas where intensified industrial activity has resulted in significant increases over natural water temperatures during drouth conditions. Future propsects for industrial development, especially in the power industry, indicate that the specific areas of concern and the over-all magnitude of the problem will steadily increase.

There is no question that regulations controlling the discharge of spent cooling waters will be adopted to protect the beneficial uses of the rivers and lakes in this country. This is as it should be. We must, however, be concerned that the regulations set forth are reasonable and equitable with proper regard for the potential impact on the industrial economy. Unrealistic controls which prevent reasonable industrial use of our water resources would have staggering economic effects on those industries dependent upon abundant cooling-water supplies. By the same token, degradation of our water resources to the extent that other beneficial users are impaired must be prevented. Recognizing that there often will be divergent philosophies regarding the equitable apportionment of scarce water resources to the beneficial users, we must rely on mature and objective judgment to resolve the conflicts and guide establishment of reasonable use. As phrased by the late Mr. Justice Holmes:

"A river is more than an amenity, it is a treasure. It offers a necessity of life that must be rationed among those who have power over it."

Unfortunately, we lack much knowledge which is essential to the evolution of sound control measures. The author points out the serious deficiencies in our experience and understanding of the effects of temperature on aquatic life. We barely have scratched the surface in studies of this kind. The current research work by Dr. Trembley is a big step forward, but it is by no means the complete solution to the problems facing us. Additional comprehensive research programs are needed to study such effects on aquatic life found in varying environments throughout the country.

Data obtained for the Delaware River near Martins Creek, for example, are not necessarily applicable to other rivers or, for that matter, to other portions of the Delaware. Co-operative efforts on the part of the control agencies and industry can increase our understanding of the effects of temperature on aquatic life and guide the development of reasonable control measures.

There is, in addition, a need for basic research on heat dissipation from lakes and streams. Some work on this subject has been done in the past, but adequate attention has not been given to such studies. If we are to be able to predict the effects of plant operations on aquatic life, we must first be able to predict the temperatures that will prevail in the river. This will require greater understanding of the factors which control the rate of heat exchange between a body of water and the atmosphere. In addition, we must devote our efforts toward development of proper methods to determine statistically the probability of occurrence of critical water-temperature periods.

I might mention here that there is no uniform set of regulations for the control of heated discharges that will allow equitable apportionment of our water resources for the country as a whole. As the author has pointed out, there are many variables to be considered in the evaluation of heated discharges on a watercourse. It is obvious that the physical characteristics of a stream or lake will vary greatly. In addition, there will be significant changes in aquatic life in streams throughout the country. We must recognize, however, that the doctrine of "reasonable use" requires full evaluation of the economic and social aspects of each power plant or industry. Dogmatic adherence to inflexible regulations is an undesirable approach to this problem.

Once we have established reliable criteria to judge temperature effects on aquatic life, and developed methods to predict temperature patterns in the receiving waters, we will then have a suitable background to establish control measures. Industry as a whole, must make a reasonable effort to co-operate in the development of these bases for judgment. It is only after these factors are well understood that we can expect reasonable and equitable control measures to be developed. Industry, and especially the steam-power industry, has a large stake in the evolution of regulations to control the discharge of heated wastes and should act accordingly.

The work reported here by the author is a significant contribution toward a desirable solution of the problem. We now look forward to the continuation of these efforts and the initiation of similar investigations throughout the country. Such studies, however, must be approached with due regard to the over-all benefit of widely divergent interests and not to unrealistic and narrow-minded viewpoints.

Comment by Eugene Gordon[8]

The author has presented interesting and valuable data on thermal pollution, a subject on which little reliable information is available. The conclusions in this paper,[2] based on ideal conditions and reliable data, indicate that the discharge of power-plant condensing water into streams does not result in the serious detrimental effects that it has been alleged they produce.

Thirteen temperature-depth profile surveys were made at four of our steam electric stations during the summer of 1960. None of these surveys indicate serious temperature effects resulting from the discharge of the condensing water into the streams.

Two of these power plants are located on the Allegheny River which is a navigable stream. The water impounded by the navigation dams forms deep, wide pools. Due to the large cross-sectional area of the stream the velocity of the water is usually low, and the condensing water discharged into these pools not only spreads across the surface of the stream, but actually will move upstream, even for flows much greater than normal low flows. However, within one and one half to two miles downstream from the power station, the average temperature of the water is only about 2 F greater than the average temperature of the water above the power station before it is affected by the heated discharge.

Although no fishing surveys have been made at our power stations, it has been observed that fishermen definitely prefer to fish in the area just downstream from the discharge of the condensing water.

A joint committee of steel and electric power companies made four temperature surveys during the summer of 1960, of

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[8] Vice-president—Power, West Penn Power Company, Cabin Hill, Greensburg, Pa. Mem. ASME.

about 100 miles of the Allegheny, Monongahela, and Ohio Rivers. Richard D. Hoak of the Water Resources Research Project at Mellon Institute coordinated these surveys and will interpret the data collected. Dr. Hoak reports that the preliminary examination of the data collected indicates that there are no harmful effects from the discharge of the heated waters into the river and that there is no tendency for heat discharge to be cumulative in effect. He also reported that dissolved oxygen readings taken every three hours around the clock, at certain locations on each of the rivers (particularly where heavy organic loading is suspected), have shown no reading below 6.9 ppm. He stated that the studies indicated that the bacterial count and chlorophyll content were the major conditions affecting the dissolved oxygen and that temperature had little effect on it.

Comment by Frank A. Ritchings[9]

This paper[2] presents interesting data and pertinent observations concerning the effect of discharged circulating water upon aquatic life in the Delaware River. It is extremely vital, with the industrial growth of our country, that research work and investigations be undertaken on this subject and the results published to counteract some of the published adverse articles. This is important since the public is becoming more aware of the problem of stream pollution and could become overzealous to the point that unnecessary regulation would be placed upon discharge of circulating water into public water bodies. Several states have laws and regulations pertaining to thermal discharges but, at present, they are all quite vague and subject to interpretation.

The following comments apply to the discharge of circulating water from steam-electric generating stations where the quantity returned is equal to the supply, is uncontaminated by the passage through the plant and is only increased in temperature.

Discharge of circulating water into a lake or river and the subsequent temperature rise of the receiving water body has been designated "thermal pollution."[10,11] This designation is a poor one since, in most cases, discharge of warm water into an uncontaminated stream will not have any adverse effect upon the aquatic life. This is clearly demonstrated both at Martins Creek Station on the Delaware River and at the many steam-electric station installations on cooling ponds and lakes which have relatively "clean" water. Fish appear to thrive exceptionally well in the vicinity of the circulating water discharge since, in innumerable locations in all sections of the country, fishing is found to be particularly good in the circulating water discharge canal.

Generally when water is clean or unpolluted, the oxygen content approaches saturation except at the lower levels in deep reservoirs. Published data[12] of experiments show that most fish can withstand water temperatures of 100 F or over if the oxygen content approaches or equals saturation. This partially explains why no fish kills have been recorded in cooling ponds which have clean water but elevated water temperatures. In the case of Martins Creek this explanation also would apply since the unpolluted condition of the Delaware River at the plant circulating water intake results in high oxygen content water in the circulating water discharge canal and the lagoon.

Another contributing factor is that the upper lethal temperature limit is dependent upon the acclimatization temperature. For example, some biologists[13] have stated that an upper limit of about 93 F should be imposed except for trout. However, if the fish become acclimatized to 93 F, they probably could withstand temperatures of 100 F or higher. The acclimatization period need only be a matter of hours to produce a significant increase in temperature tolerance. There is, however, an upper limit beyond which fish cannot survive for more than a few hours regardless of the degree of acclimatization and dissolved oxygen concentration. This limit is in the range of 104 to 106 F for the finer fish and slightly higher for the coarser fish such as catfish, gar, and dog.

Another item, to take into consideration when discussing temperature limits, is that biologists normally consider temperature limitations in relation to the environment which will result in good fish propagation. When considering temperature limitations relative to steam-electric plant operation, it should be borne in mind that maximum water temperatures will usually occur in the summer well after the spawning season and that the temperature rise in the stream or lake is not sudden but rather a gradual rise following the natural water temperature rise after compensation for the variation in stream flow.

Furthermore, consideration also should be given to the river conditions and water use downstream of the plant. At Martins Creek Station, the mixing and aerating effect of Big Kapush Rapids apparently prevents the formation of a warm water stream along the Pennsylvania shore and raises the oxygen content of the water sufficiently to prevent any decrease in oxygen content which might result from increased oxygen consumption rate that would occur when the water is warmed. Not every plant is as favorably located as Martins Creek with relation to the natural reaeration features and the lack of industrial activity immediately upstream or downstream of the plant.

In many instances the water at the plant intake is polluted or is polluted by others below the plant discharge. At such locations, temperature rise would affect the rate of "self-purification" of the water since an increase in temperature causes the rate of decomposition of organic matter to increase thereby raising the rate of oxygen consumption and correspondingly decreasing the oxygen content of the water. Increase in temperature also increases the rate at which water reaerates itself but, unfortunately, the rate of oxygen consumption by decomposition process rises more rapidly than the rate of reaeration. In these situations a means for aerating the circulating water discharge before return to the stream may be desirable. Construction, where practical, of a drop structure incorporating riffles in the circulating water discharge canal, would aerate the water. Experience has shown this method to be quite successful in adding up to 3 ppm of dissolved oxygen to the discharged circulating water depending upon the dissolved oxygen content of the water at the condenser outlet and the water temperature. Other methods are presently being employed but each must be designed with respect to the individual situation.

It is apparent that steps should be taken to:

1 Conduct or sponsor research to determine the relationship of acclimatization temperatures to lethal temperatures for all popular sport fish and also the effect of dissolved oxygen content upon this relationship.

2 Conduct or sponsor extensive ecological studies to determine actual conditions in the vicinity of power plants with respect to water quality, fish, and aquatic life. Where possible these studies

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[10] Edward W. Moore, "Thermal Pollution of Streams," *Industrial and Engineering Chemistry*, vol. 50, April, 1958, pp. 87A–88A.

[11] Ronald H. Laberge, "Thermal Discharges," *Water & Sewage Works*, vol. 106, December, 1959, pp. 536–540.

[12] John Cairns, Jr., "Effect of Heat on Fish," *Industrial Wastes*, vol. 1, May-June, 1956, pp. 180–183.

[13] C. M. Tarzwell, "Water Quality Criteria for Aquatic Life," *Transactions of Seminar on Biological Problems in Water Pollution*, R. A. Taft Sanitary Engineering Center, 1956, pp. 246–272.

should be carried on before and after construction of the power plant.

3 Publish detailed results of these studies in Items 1 and 2 and keep state water-pollution authorities fully informed.

If these steps are undertaken, both the utilities and the pollution-control authorities would be better informed and thus be able to develop more realistic regulations.

Comment by S. F. Whirl[14]

Both the author and his company are to be complimented on this original and worth-while contribution to an extremely complex subject on which there is certainly a dearth of reliable information. Little is known concerning how small temperature increases, in localized areas, affect animal and plant life in rivers and streams. Is microbiological growth sustained or destroyed? Is aquatic life reproduction interrupted? Does plant life disappear? Or do both fish and plant life adjust to the local condition and continue their normal growth? The author has supplied this information for one localized area constituting approximately 1,200,000 sq ft, and has found no condition deleterious to plant or fish life. Similar studies at many other plant sites under the individual conditions that prevail can create a pool of knowledge for evaluating thermal effect wherever it might occur.

Electric utilities are community-conscious, they are good neighbors, and necessarily so; the growth of any power company is dependent on the community well-being. Commerce, industry, civic conscience, education, and recreation, all contribute to the community's prosperity. Clean air and clean streams are today a matter of civic pride safeguarding both health and recreation. Electric utilities are actively engaged in activities which make the community a better place in which to live. The Duquesne Light Company participated in much of the pilot work in the control of air pollution, contributing measurably to Pittsburgh's Renaissance. This work was carried on long before air-pollution legislation was enacted, and furnished basic information necessary to draft a practicable air-pollution ordinance.

Now, we are embarking on a similar project in regard to stream pollution, particularly as it may be affected by temperature increase. Here, again, we need similar basic information. This will require co-operative studies by representatives of commerce, industry, civic-minded groups, and government to determine a practicable solution to the problem.

Initiated by the Pennsylvania Electric Association, industry in the Pittsburgh area already has began a co-operative study at selected locations on all of its three rivers—the Allegeheny, Monongahela, and Ohio. The Duquesne Light Company is also represented on the Advisory Committee for Control of Stream Temperature, appointed by the Division of Sanitary Engineering, Pennsylvania Department of Health.

Another investigation, which has been in progress for the past two years, stems from a clause in the Operating Permit for the Shippingport Atomic Power Station which reads as follows:

"The permittee is hereby advised that the river water temperature rise is tentatively limited to 2 F at points to be determined by the Sanitary Water Board after the results of the thermal studies of the channel and of other data have been reviewed, and that if this limit cannot be maintained with the proposed method of discharge, then complete dispersal of the condenser effluent in the river, or other means for temperature control, may be necessary."

Temperature readings are being taken in accordance with a planned program; this study is still in progress.

It is earnestly hoped that this complex problem will be given deserving consideration, that advantage will be taken of every opportunity to gain new and vital information, and that eventually, workable, yet effective legislation will be enacted. Until this basic information is available it would be wise to hold in abeyance, any legislation which could prove inadequate, unfeasible, economically unsound, or detrimental to the commonwealth.

Comment by J. D. Williamson[15]

The work which the author and his company have done in studying the effect of condensing water discharged into a river is both timely and necesssary. If we, who are in the business of generating power, are going to be subject to state regulations on this matter, a great deal of educational work will need to be done.

The work done by the Pennsylvania Power and Light Company indicates that the discharge of condensing water into a river does not produce the ill effects which some have claimed. In fact, this paper indicates that it may have certain advantages.

The danger of regulations on this matter is that they will probably not consider rivers individually. We have a 410-mw station located on the Great Miami River in Dayton. About eleven miles downstream we have a 360-mw station. Minimum flows of 200 cfs are not uncommon during the summer and fall months, and the historical minimum flow was 109 cfs. The latter occurred with one power plant on the river, and it had a capacity of only 220 mw at that time.

This stream is quite wide and therefore quite shallow in many locations. We have never run a temperature survey as thorough as the one conducted at Martins Creek. However, we have checked temperatures of the river between the two stations and for several miles below the second station. We discovered that the temperature returns to normal about three miles below the point where the condensing water is discharged into the river. We noticed also that, due to the shallowness of the river, the temperature will increase again beyond this point due solely to the heat from the sun.

Thus it would seem that we have problems on this river that are not common to deeper streams and those with minimum flows.

Comments by B. B. Owen, et al.[16]

The author states the fact that the Institute of Research of Lehigh University has conducted research on the subject to which his paper[2] is addressed. This research, under the direction of F. J. Trembley, professor of Ecology at Lehigh, has been sponsored by the Pennsylvania Power and Light Company. We are grateful that the author only implies but does not state explicity that his remarks are based upon or accurately represent the findings of this research. In each of the five sections of the paper are statements which contradict research findings as reported to the Company, or which present "facts" not established by the research, or which are misleading because of omission or distortion of parts of the data.

A reasonable approach to a potentially lengthy discussion is to review the conclusions. At the outset, the author's remark "Little substantiated information is to be found, and that which is available is insufficient to permit reliable conclusions" in our opinion is still applicable to

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[16] B. B. Owen, associate professor of Biology, Lehigh University, and acting director of the research project on Condenser Water Discharge Effects. The Director, Dr. F. J. Trembley, professor of Ecology, although on leave, has reviewed this discussion and concurs fully with it. Others participating include Dr. B. W. Parker, professor of Biology and head of the department, J. A. Mihursky and Mrs. Eleanor Hertz, research assistants, and G. R. Jenkins, director of the Institute of Research, Lehigh University.

the value judgments he offers in the paper. With this reservation, the research findings are sufficiently consistent with the author's conclusions numbered 2, 4, 7, 8, 9, and 11, that specific discussion of these is not required although some of them are questionable extensions of the research findings. This comment, then, pertains to the remaining conclusions and the parts of the paper devoted to them.

1 Conclusion 1, pertaining to distribution of heated water after discharge to the river.

Assertions are made by the author that "the temperature of river water at the bottom of the river is unaffected" and again "is usually not affected." The first of these assertions refers to the entire area affected by the discharge, but it appears to be based solely upon a single temperature-depth profile, one of only three which were made 3100 (cf. 2100 ft in caption for Fig. 2) ft below the point where the hot water is discharged into the river. Moreover, the reader is not informed that the one selected for presentation in the paper and used for the generalization quoted was made on a day when one of the two generators at the plant was not operating. The reader is also not informed concerning seven temperature traverses which were made at the railroad bridge (1500 ft below discharge). In these traverses, surface and bottom temperatures were measured and showed very close agreement throughout the width of the heated zone.

With respect to Fig. 2, the interpretation is given that heated water extended only 2 ft 6 in. below the surface and left 85 per cent of the water of the river unaffected. This interpretation is probably not justified even for conditions on the day when the profile was made. The "average normal" river temperature of 80 F shown in that figure was taken from the water intake by a thermocouple temperature recording instrument located at the plant. All other temperatures were taken by use of a thermistor, a more accurate instrument. Since the temperature on the Jersey side of the river is shown in Fig. 2 to be 78.8 F, the reader might conclude that this rather than 80 F should represent the "average normal." Such revision greatly increases the depth and area containing water above normal temperatures on the profile. The pertinent research report states that the minimum temperature observed at the railroad bridge on the Jersey side of the river represents normal river temperature for such comparative purposes. Nevertheless, the use of the 80 F criterion has not been changed since the original preparation of the drawing. For this, the research personnel must share some responsibility, although we avert that by recommending repeatedly that more temperature-depth profiles should be taken, we have established our rejection of Fig. 2 as being representative of actual temperature distributions and as being suitable for use in a publication without full explanation of its limitations.

"The greater flow of the river returned the temperature of the surface water along the Pennsylvania shore to within 4 F of intake water temperatures 2100 ft downstream from the railroad bridge and to within 1 F, 3000 ft downstream." This refers to the lower part of Fig. 1, illustrating conditions when river stage was high. It is subject to the qualification that again the thermocouple record of intake water temperature was considerably higher than the thermistor readings. If one takes the Jersey side temperatures as normal river value, the temperature at 3000 ft below the bridge, hence 4500 ft below discharge, is 4 or 5 F above normal, not 1 F. This view is further sustained by a series of temperature readings taken weekly for one year, all by the same instrument, a calibrated field thermometer, during the collection of periphyton samples. Temperatures were measured in the river near the intake and at a point on the Pennsylvania side 4500 ft below the discharge. These data show that at this point river temperature averaged 3.4 F above normal river-water temperatures at intake.

The author, referring to the second set of traverses in Fig. 1 and presumably other data, notes "Surface water temperatures had pretty well returned to normal at 4500 ft downstream from the point where the discharge canal enters the river." Actually, the upper part of Fig. 1 shows an average temperature of about 78 F at 4500 ft below discharge compared with intake temperature of 72 F, a value which is also consistent with the actual normal value for the river on that day. The upper part of Fig. 1 specifically negates the conclusions drawn from the lower part. On analysis, the two parts of Fig. 1, as well as the misleading interpretation of Fig. 2, illustrate very well the difficulties of utilizing the thermocouple temperature recorder to establish normal river temperatures.

2 Conclusion 3, pertaining to effects on plant life.

The author asserts that "all in all it can be stated that the aquatic vegetation of the river was not materially changed by the discharge of condensing water." Prior to this he stated "This type of vegetation (blue-green algae) is present in very small amount" and "The blue-green algae in the area below the discharge canal were minor in amount." These statements contradict the research findings of drastic reduction of rooted aquatic plants on the Pennsylvania side of the river for at least 1500 ft below the discharge, and of a marked increase in the growth of objectionable blue-green algae over a length of at least 2500 ft in the river, with a concomitant suppression of normal growth of most other algae. In addition, the entire discharge canal contains for a greater part of the year a massive growth of blue-green algae. These changes in rooted aquatics, blue-green algal and periphyton distributions, were clearly reported to the Company. Fig. 3 of the paper does not itself support the statements quoted.

3 Conclusions 5, 6, and 10 pertaining to fish and fishing.

In conclusion 6 and other statements, the author asserts that there were no fish kills in the river resulting from the discharge of condensing water to the river. This contradicts the research findings of fish kills in the heated water of the river as well as in the effluent canal, as given in three different progress reports. These reports included direct observations of fish in the river actually seen dying with symptoms known to be associated with heat death.

The statement, "Since fish kills take place to about the same extent both upstream and downstream from the station" apparently refers to a single observation on May 15, 1957, when 208 dead white suckers were counted, along with 23 fish of other species, on both shores between Delaware Water Gap and Phillipsburg. As stated in the report, the white suckers probably died as they sometimes do in connection with annual spawning activities.

The pertinence of conclusion 5 that "fish have the ability to stay out of areas of the river where the temperature of the water is not to their liking" is doubtful in view of the record of fish kills in the river by the heated water. It also must be held in reservation until the temperature distribution is more thoroughly investigated to determine whether or not conditions may occur that might prevent avoidance of heated water by fish.

In this connection, the observation "During the heat of summer the water in this lagoon reaches temperatures considerably above the reported LD-50 temperatures for these fish. In spite of this they survive, are active, strike at lures, and provide good fishing" is a serious misinterpretation. The research reports note a few occasions when fish did bite when the thermometer showed water as hot as 104 F. However, the author should include the information that the upper end and bottom of the lagoon con-

tain cooler water in which the fish can find refuge, where in fact they seem to be trapped, become very hungry, and indeed do strike through the hot water at lures. In any case, it is inappropriate to use the expression "in spite of this" since it logically follows by definition that the more temperature tolerant 50 per cent of fish will ordinarily survive the LD-50 temperature.

Conclusion 10 that "fishing in a river is improved as a result of the discharge of condensing waters" is seriously misleading. It is an unwarranted extension of conclusions 7 to 9, inclusive. Other findings pertinent to the fisheries biology of the site are in some respects favorable to improved fishing and in other respects, unfavorable. As might be expected, present data are insufficient to permit drawing a broad generalization such as conclusion 10. It is obvious that the observations at the particular site, although pertinent, have not established the generalization except for the immediate reach under the existing conditions of water use. For fishing to be improved in any body of water on a long-term basis, there must be an increase in reproduction, survival, and growth. The extent data are only part of those necessary to consider "a river," whatever the author may mean by this language. We also have no evidence that research has been conducted on any other river with sufficient thoroughness to verify such a generalization.

In summary, the caption under the title of the paper proclaims, "This study shows no harmful effects to fish or plant life." The research findings include evidence of fish kills, massive blue-green algal growths, and alterations in other forms of life observed in the heated water zone. A return to upstream conditions has not yet been demonstrated conclusively in some cases even at 4500 ft below the discharge. These conditions certainly constitute "harmful" effects in the eyes of many who are concerned with water quality and use. It appears to be not only false but a totally unnecessary remark.

It is apparent from the list of six conclusions which have not been discussed, that there are valid considerations that pertain without prejudice to the net consequences of heated water discharge at the rates now prevailing at the Martins Creek S.E.S. By including materials which are at variance with the research findings, the author vitiates the value of his paper. This is notable because the progress of the research has been revealed, with Company participation, to persons in industry and Federal and State agencies who by their positions and training are likely to be especially perceptive. The research has been reported in privileged communications to others, and has been partially published as follows:

F. J. Trembley, "Effects of Heated Industrial Effluent Water." Proceedings of the Eighth Annual Conference, Pollution Abatement Committee, Pennsylvania State Chamber of Commerce, Harrisburg, Pa., May, 1960 (mimeo).

Comment by J. D. Ristroph[17]

The author has ably presented a most timely subject—that of the effects of thermal pollution and stream pollution in general. The Virginia Electric & Power Company has been engaged in research and study of the effects of the temperature and other involved factors, such as the limnological aspects, on streams and bodies of water for a number of years. We were abruptly faced with this problem in connection with obtaining a license for a hydroelectric project—yet little had been published on the subject other than in civil-engineering journals or textbooks normally not found in utility libraries or reference files. There is a serious need of current information.

Our studies were of great magnitude and were made in co-operation with various consulting and engineering firms and state and federal agencies. An idea of the scope can be gained by the fact that more than 15,000 analyses were made in one summer. These tests still continue and a survey of some 90 miles of the river, including two hydroelectric reservoirs, is made every two weeks during the critical period and once monthly in the winter months. Here must be considered the fields of ecology and limnology with the attending complexities of the hypolimnium, the epilimnium, thermoclines, diurnal cycles, and photosynthesis. To these factors, we could also add the compounding effects of industrial and municipal sewerage.

From our experience on this river and from many and diverse studies at our thermal power stations, we can find general agreement with the findings of the author. These tests at a number of power stations show that the heated water tends to spread out on the surface, with cooling resulting from ambient cooling, evaporation, and some interfacial mixing of the layers of water at different temperatures. Temperature gradients soon disappear and only minor distances of the stream are affected.

Our findings indicate that rapid changes in temperature are suspect in fish kills. We can cite a case of a large fish kill of gizzard shad in our Roanoke Rapids hydroelectric impoundment. At this time, the oxygen content was high and there was no evidence of any contributing cause other than a relatively quick temperature depression. Similar cases can be cited. It is believed that fish and other aquatic life can accommodate to gradual temperature changes and become acclimated.

Relative to desired minimums of dissolved oxygen, fish can live and have been found in areas where the dissolved oxygen content of the water was well below the value cited in textbooks as the irreducible minimum conducive to sustenance of aquatic life.

We certainly can agree with the author that fishing, especially in the winter months, is especially good in the area of condenser discharge. Perhaps the best indication of this is the fact that this is the point of greatest concentration of anglers—and you can't fool a good fisherman!

The discusser attended a symposium several years ago at which one of the learned speakers expressed a fear that the "efficient air removal apparatus" in utility plants would effectively remove and materially reduce the dissolved oxygen in condenser discharges. This erroneous thinking is sometimes typical of those unacquainted with the actual facts.

A study was made at the outfalls of some of our thermal stations a number of years ago. Tests for temperature and dissolved oxygen content were made at the intake and discharge of our circulating water systems. The per cent saturation could then be easily computed.

The bar graphs illustrate the conditions found. It will be noted that there is a slight drop in oxygen content only when the inlet water is saturated with respect to oxygen content. This would occur normally during the colder winter conditions when dissolved oxygen is not as important a factor in open waters because of the high levels of dissolved oxygen that exist and because of the lower rates of reaction with organic matter at these depressed temperatures. It will be noted that the percentage saturation remains at 100 per cent. (Possum Point Units 1 and 2. See Fig. 2.)

Where the inlet water is not initially saturated with dissolved oxygen, usually in the critical summer and early fall months, it will be noted that we have an increase in per cent of saturation and the quantity of dissolved oxygen, expressed as parts per million, is practically unchanged. (Yorktown, Chesterfield, and Twelfth Street Stations. See Figs. 1, 3, and 4.)

Of course, condenser design relative to one or two pass construction and the design of the outfall can influence these

[17] Manager of Power Production, Virginia Electric & Power Company, Richmond, Va.

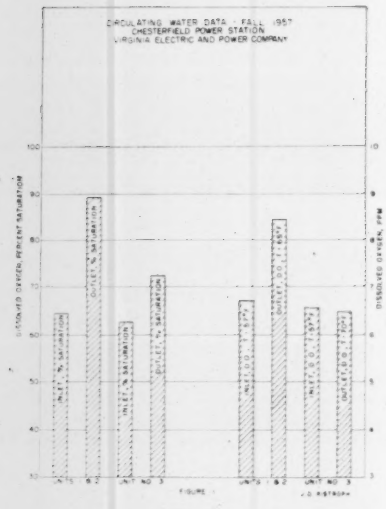

Fig. 1

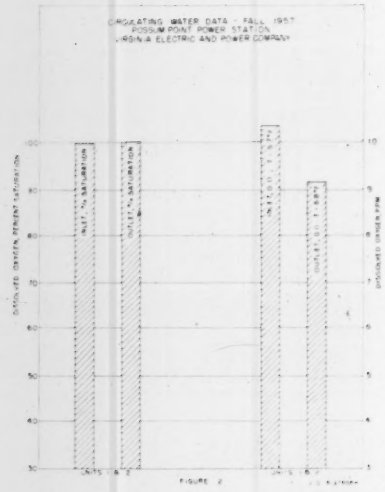

Fig. 2

Fig. 3

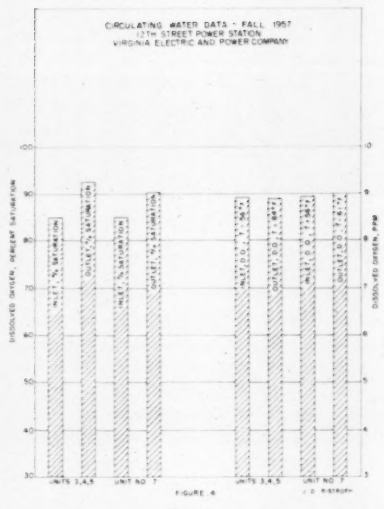

Fig. 4

values. It can be seen that units of proper design do not affect materially the dissolved oxygen content of the discharge.

The need for public dissemination of data on studies on stream pollution is urgent. We cannot expect our state legislative bodies to be experts on these matters and in reality even many experts find serious grounds for disagreement among themselves. It is suggested that our utility and industrial firms can well afford to engage in constructive research on this matter of stream pollution in order to more actively participate in the formulation of intelligent workable legislation which will take into consideration not only the conservation of natural resources but also the reasonable economic welfare of the users of the stream and the industrial development of the area. It has been our experience, in the tri-state areas, that the regulatory authorities have been co-operative and appreciative of such efforts.

Comment by Charles B. Wurtz[18]

The author has given a lucid description of the work done by Dr. F. J. Trembley, his students, and colleagues. This work is of interest to all who are concerned with heated discharges.

In his conclusions, he states that local conditions govern the aquatic effects resulting from the discharge of the condensing water from a power plant to a river. He goes on to state that each case should be individually studied. However, it would have been helpful if he had indicated some generalizations, even though tentative.

Our own work in Pennsylvania, plus the work of others (much of which is unpublished to date) would, tentatively, indicate that the reduction of thermal loading in a natural channel is intimately associated with the hydraulics of flow. In general, shallow streams with rough channels and higher turbulence tend to limit the lateral spread of a discharge. In such streams the discharge tends to hug the bank of its origin. The Delaware River at Martins Creek appears to be of this nature. Conversely, deeper streams with smoother channels and lesser turbulence tend to accentuate the lateral spread of a discharge. Since these conditions represent either end of a continuous variate all intermediate conditions should be found. Velocity of flow must play a conspicuous part in the pattern of distribution of a discharge. Phelps (Stream Sanitation, 1953) tells us that the retarding effect of sewage on reaeration is increased with higher rates of turbulence. Is this applicable to heat reduction?

One corollary of this is the greater distance a heated discharge can be traced in the shallow, turbulent stream. A contradictory aspect (to a nonengineer) is the laminar surface flow described.

Contrary to some published comments, there does not appear to be sufficient data available to support the contention of a permanent heat increment in a river by only a single heated discharge. Such increments appear to be derived from repetitive discharges, and these are not necessarily cumulative.

Some discussion of aquatic vegetation is offered by the author, but most of the river biology studied at Martins Creek relates to the fish. It is unfortunate that fish are viewed as the epitome of biological usefulness in an aquatic habitat. Both trickling filters and activated sludge tanks are aquatic habitats that do not support fish. Both are more important to our human culture, comfort, and economy than all the bass and walleye pike in North America. An undue emphasis upon recreational fishing carries an inherent implication that the elimination of fish from a particular part of a stream constitutes biological destruction of that part. This is not true. Many surface waters lack a fish fauna, but they are still biologically active. The activities of our citizens and the physiography of our nation reduce our fishermen to a minority group. They should not be encouraged to expect that every acre of water will be held for their interest. They must bear in mind the lamentation of the prophet (Isaiah 19:8): "The fishers also shall mourn, and all they that cast angle into the brooks shall lament, and they that spread nets upon the waters shall languish."

[18] Consulting Biologists, Inc., Philadelphia, Pa.

Notes on Books Received in Engineering Societies Library

REVIEWS OF BOOKS

The Senator From Vermont

The Senator From Vermont

By Ralph E. Flanders. Little Brown & Company, Boston, Mass., 1961. Cloth, 5½ × 8¼ in., 312 pp., $5.

Reviewed by William L. Batt[1]

REVIEWING a new book by a Past-President of The American Society of Mechanical Engineers is not the easiest assignment one could think of. One can never be unmindful of the fact that such a man is likely to be a man of importance and anything he writes is sure to have a background of wisdom and experience. But, to make the problem more difficult, the reviewer may be an old and close friend of the author and may well lack an adequate objectivity as he appraises the author's self-portrait. For this book is Ralph Flanders' story of his own career, beginning with his boyhood days in Vermont and carrying the reader through a busy and highly useful life to his recent decision to retire from Senatorial life.

The book under review is an interesting book and well worth a wide readership. It is the work of an intensely thoughtful man. It pictures a life of a wide variety of activities, all with depth and purpose. From beginning to end, it is the chronicle of a serious-minded individual who is constantly motivated by high moral principle and a determination to press toward an objective regardless of opposition.

As one sees how this Vermont boy was brought up—his background, his family life, his schooling—such an attitude toward life is easy to understand.

Reading the first sections of the book, in which these boyhood experiences are so interestingly described, raised some serious questions in this reviewer's mind about the way of life of the youngster of today. What can one conclude about the moral stamina and the roots of character of the child of our time glued in all his spare time to the radio and television; too frequently little or no responsibility for any share of work around the house; a lack of consciousness of family sharing and family unity?

I conclude that this portion of the Flanders book impressed me deeply; made the whole book well worth-while, had there been no other rewards. Of course there were, and it may well be that I got less from them relatively because they were more familiar to me. But the picture of that little Flanders family, not well off materially even in the standards of that day, all sitting around the large kitchen table after the supper dishes had been removed. The one really good kerosene reading lamp in the center; father reading or checking up on his family accounts; mother darning or mending; the children doing their homework as a part of that busy, intimate family circle. Doesn't this give a child something of a deep and permanent character? Isn't his sense of responsibility to his family, his community, and his own life matured on the only really sound basis? Certainly this story of the upbringing of a typical Vermont boy raised grave questions in my mind. I cannot fail to ask if, in giving our children of today so many material comforts and luxuries, we are not keeping away from them some hardening and refining qualities that would make them more self-contained and useful adults.

I doubt if the author thought of this portion of his book as one of much interest compared to what was to follow from his mature years, but it left an unforgettable impress on my mind.

As to the body of the book, I confess to some small disappointments. In his foreword, Flanders explains that he is writing for his family, particularly his grandchildren. This could explain his use of a great deal of space on his travel experience, not of particular interest to you or me, and he omits or understresses his many contributions to engineering, industry, and public life.

Page after page quotes from speeches and various writings of the author. Much of this seemed to me needlessly detailed and of little general interest. My disappointment, if that is not too critical an expression, arises from the fact that Flanders does not treat, with all the philosophical thoroughness of which I know he is capable, some of the major social contributions he has made. He has certainly been an outstanding pioneer in the development of a new and revolutionary concept of managerial responsibility. In his active lifetime—indeed in just the past quarter century of it—he has seen and participated actively in changes in the relationships between employer and labor, whose consequences are too far-reaching to be adequately evaluated even now.

One would like to have seen a more vigorous discussion of the author's part in this great movement, because his attitude was always sufficiently objective to qualify him more as a judge than merely an advocate.

The same observation could perhaps be made as to his rather casual comments on his connection with the profession of mechanical engineering and with his Presidency of this great Society. His contributions in the field of standardization, it seemed to me, warranted a more detailed coverage, particularly as this area of engineering achievement has had such a profound effect on the American economy.

.Perhaps these friendly criticisms may sufficiently annoy our fellow engineer to bring him to write another book—one which will go into some greater detail as to his philosophical reactions in these fields of great human change where he has had such an active part.

Flanders makes one most interesting observation in his book which, in itself, is of enough significance to warrant a more detailed discussion. He advances the proposition that an engineer, trained to evaluate facts, may well fail completely in the field of diplomacy where facts are likely to give way to compro-

[1] Retired president, S.K.F. Industries, Philadelphia, Pa. Past-President and Hon. Mem. ASME.

mise. As one looks dispassionately at Senator Flanders' effectiveness in the Senate of the United States, one may, I think, ask if his training as an engineer and his unwillingness to swerve may have limited his effectiveness. Public life is largely a matter of compromise, and legislation most certainly is. The qualities of greatness which are inherent in Flanders' life may have led me, as an old friend, to expect more from him in the way of bills bearing the Flanders' name than came about. Could it be that here one found the necessity for compromises which, to Flanders, were difficult?

Doubtless it was this unwillingness to compromise where he thought principle was involved, that gave the Senator from Vermont the determination to meet Senator McCarthy head on at a time when other Senators seemed to find an attitude of evasion the safest one. This took real courage. Flanders was not, of course, the only man in a position of public responsibility who saw great and fundamental danger to our democratic institutions; there were many in high places who deplored what was going on under the guise of protecting the country from communism, and yet failed to protest. McCarthy had shown such a capacity for unrestrained and bitter attack on his critics that there was everywhere a disposition to give him as wide a berth as one does a certain attractive animal with an extremely unattractive and odorous attack.

It may well be this one sturdy assertion of decency and right which will forever serve as Flanders' monument in the Senate of the United States.

No appraisal of his life's work can fail to recognize and praise it.

The ASME has reason to be proud of this Past-President and will, I am sure, find his book thoroughly good reading. I commend it to my fellow members.

Symposium on Fatigue of Aircraft Structure

Published 1960 as ASTM Special Technical Publication No. 274 by the American Society for Testing Materials, Philadelphia, Pa. 138 p., $6^1/_4 \times 9^1/_4$ in., bound. $4. Presents nine of the 12 papers given at the Symposium. Of the remaining three, two will be published later and one has been withdrawn. Topics covered include the handling of fatigue data in a practical design case, probable loading conditions encountered by aircraft, supersonic fatigue test methods, fatigue behavior under high biaxial stresses, helicopter problems, methods for improving fatigue behavior, methods for predicting rates of fatigue-crack propagation and cumulative damage due to variable-amplitude loading.

Symposium on Newer Metals

Published 1960, as ASTM Special Technical Publication No. 272, by The American Society for Testing Materials, Philadelphia, Pa. 218 p., $6^1/_4 \times 9^1/_4$ in., bound. $7.25. The three sections of this text correspond to the three sessions of the Symposium. Section 1, "Properties of refractory metals," includes papers on high-temperature testing methods and properties of molybdenum, tantalum, columbium, and the platinum-group metals. Section 2, "Nuclear and light metals," includes papers on beryllium, zirconium, and yttrium. Section 3, "Processing of newer metals," is concerned with purification and fabrication of columbium, tantalum, molybdenum, chromium, and lithium. An additional paper is included in this volume to supplement the information on zircaloy alloys, dealing with the application, to the analysis of zircaloy, of coulometric determination of tin.

Symposium on Spectroscopy

Published 1960 as ASTM Special Technical Publication No. 269 by the American Society for Testing Materials, Philadelphia, Pa. 245 p., $6^1/_4 \times 9^1/_4$ in., bound. $7. This volume contains 16 papers presented at the Symposium dealing with such topics as atomic, x ray, infrared, molecular, ultraviolet, magnetic resonance, and electron paramegnetic resonance spectroscopy, flame photometry, infrared, and spectroscopic analysis, and applications in geochemistry, petroleum technology, and other fields. Also included is a nonsymposium paper dealing with application of spectrography to the analysis of water formed deposits.

BOOKS RECEIVED IN LIBRARY

La Theorie des Gaz Neutres et Ionises

By E. W. Montroll and others. 1960, John Wiley & Sons, Inc., New York, N. Y. 469 p., $7 \times 9^3/_4$ in., bound. $17.50. This volume contains material presented at the ninth (1959) session of the summer school in theoretical physics at the University of Granoble, France. The nine sections are self-contained, and usually include extensive bibliographies. Five sections are by American scientists, and discuss statistical mechanics of interacting particles; plasma in a strong magnetic field; asymptotic theory of systems of ordinary differential equations; Landau damping; and plasma transport theory. One section from the Netherlands presents lectures in English on statistical mechanics of nonequilibrium phenomena. The remaining contributions are from France, in French, and deal with the microscopic theory of ionized gases; electromagnetic waves in plasmas; and the role of plasmas in astrophysics.

The Theory of Thin Elastic Shells

(Proceedings of a Symposium of I.U.T.A.M., Delft, 1959)
Edited by W. T. Koiter. 1960, Interscience Publishers, New York, N. Y. 496 p., $6^1/_4 \times 9$ in., bound. $9. The 23 papers presented at this symposium (5 in German, 1 in French) discuss two aspects of shell theory—nonlinear theory and problems lacking axial symmetry. Frequently papers from two or more sources deal with the same topic, indicating simultaneous investigations in different countries, but these present different points of view and, collectively, a broad perspective of each problem.

Unsteady Motion of Continuous Media

By K. P. Stanyukovich. 1960, Pergamon Press, Inc., New York, N. Y. 745 p., $6^1/_2 \times 10$ in., bound. $15. This edited translation contains a restatement of classical theory, and a complete account of the contributions to the science by Russian scientists. These contributions reflect work with classical problems and with the many new applications in problems of explosions, fission or fusion reactors, and the motion of space vehicles.

Winning Coal

By John Sinclair. 1960, Sir Isaac Pitman & Sons, Ltd., London, England. 406 p., $5^1/_2 \times 8^3/_4$ in., bound. f 3.00. Written for those preparing for British professional degrees and technical certificates by a specialist in mechanized mining, this book considers all methods of coal production at the face. An opening survey of open cast production is followed by concise treatment of the older hand-worked methods. The next five chapters deal in detail with methods of mechanized mining, including the panel and block systems in room-and-pillar mining, coal cutters, loaders, continuous miners, and cyclic and noncyclic longwall mechanization. The last two chapters deal with the use of explosives and substitutes such as cardox, hydrox, and compressed air.

Advances in Petroleum Chemistry and Refining, Vol. 3

Edited by John J. McKetta, Jr. 1960, Interscience Publishers, Inc., New York, N. Y. 544 p., $6^1/_4 \times 9^1/_4$ in., bound. $16.80. Seventeen contributors from industry present critical evaluations of current practice and recent developments in this field. The papers are arranged in five groups. "Economics and future trends" discusses the economics of petrochemicals; "Unit operations and design" has sections on liquid thermal diffusion and fired-tube heaters; "Refining processes" covers the mechanism of hydrocarbon isomerization, the hydrogenation of petroleum and its fractions, and hydrofluoric acid alkylation of paraffins; "Petrochemicals" includes discussion of hydrocarbon oxidation, the manufacture of petrochemical acetylene, and the chemistry of the sulfur compounds in petroleum; "Mechanical equipment" reviews recent advances in cooling towers.

Advances in X-Ray Analysis, Vol. 3

Edited by William M. Mueller. 1960, Plenum Press, New York, N. Y. 376 p., $6 \times 9^1/_4$ in., bound. $12. This volume contains 23 of the papers presented at the eighth annual conference on applications of x-ray analysis, held in Colorado in August, 1959, and sponsored by the Denver Research Institute of the University of Denver, and two papers from the seventh conference. The papers discuss developments in the fields of x-ray absorption, fluorescence, diffraction, and instrumentation.

Air Pollution Manual, Part 1: Evaluation

Published 1960 by the American Industrial Hygiene Association, Detroit, Mich. 194 p., $8^3/_4 \times 11^1/_4$ in., bound. $8.50. Prepared by

a group of engineers, chemists, toxicologists, physicists, meteorologists, and others specializing in the field of industrial hygiene and air pollution, this book presents information needed for the intelligent appraisal of air-pollution problems. It is a practical book, containing discussions of the methods, techniques, and instrumentation relevant to investigations of each problem, as well as literature references to proved sources of information. Vol. 2 to follow, dealing with air-pollution control.

American Men of Science: The Physical and Biological Sciences, F-K

Edited by Jaques Cattell. Tenth Edition. 1960, The Jaques Cattell Press, Inc., Tempe, Ariz. Vol. 2 of four volumes, $8^3/_4 \times 11^1/_4$ in., bound. $25. "American Men of Science" gives brief biographical data, including education, positions, and special fields of research. The 10th Edition covers the physical and biological sciences together in four volumes, of which A-G, and now F-K have been published. Volumes L-R and S-Z will appear by early 1962, preceding by some months publication of the fifth volume of this edition, which concerns the social and behavioral sciences. Each of the five volumes will contain approximately 24,000 names.

Analog Computation in Engineering Design

By A. E. Rogers and T. W. Connolly. 1960, McGraw-Hill Book Company, Inc., New York, N. Y. 450 p., $6^1/_4 \times 9^1/_4$ in., bound. $16. Emphasizing application rather than design and operation, this book demonstrates the use of the general-purpose analog computer in the solution of industrial problems. The brief introduction describes the principles, capabilities, and limitations of the computer. There follows a concise review of pertinent topics from engineering mathematics, and a full treatment of computer methods of solution. The final section is an analysis of real problems taken from industry, illustrating efficient problem preparation and computer solution.

Cermets

Edited by J. R. Tinklepaugh and W. B. Crandall. 1960, Reinhold Publishing Corporation, New York, N. Y. 239 p., $6^1/_4 \times 9^1/_4$ in., bound. $9.50. Twenty-three authorities in the field of high-temperature materials here discuss the fundamental aspects and properties, forming and processing, testing, and applications of oxide and carbide-base cermets.

Chemical Analysis of Cast Iron and Foundry Materials

By W. Westwood and A. Mayer. Second Edition. 1960, George Allen & Unwin, Ltd., London, England. 586 p., $6^1/_2 \times 9^1/_2$ in., bound. 63s. This book describes general laboratory practice and apparatus in the sampling and chemical analysis of pig iron, cast iron, ferro alloys and ladle additions, iron ores, annealing ores, slags, refractory materials, linseed oil, and coke. The methods derive from work of the British Cast Iron Research Association, and the British Iron and Steel Research Association, and are described sufficiently to be used by junior assistants. This volume is published because of exhaustion of the first edition, but methods have been replaced or modified where necessary to accommodate and incorporate new advances and the latest British Standard recommendations.

Chipless Machining

By Charles H. Wick. 1960, The Industrial Press, New York, N. Y. 502 p., $6^1/_4 \times 9^1/_4$ in., bound. $10. This book describes production processes for the cold working of steel, the essential steps in making parts by these methods, the design of equipment and tooling necessary for the use of the processes, typical applications, and the economics of moving metal rather than removing it. Working data are included on such processes as spline and gear rolling, radial forging, power spinning, cold extrusion, and explosive and other high-energy-rate forming.

LIBRARY SERVICES

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Computer Engineering

Edited by S. A. Lebedev. 1960, Pergamon Press, New York, N. Y. 184 p., $5^1/_2 \times 8^3/_4$ in., bound. $10. This translation from the Russian contains papers discussing the power supply of the high-speed electronic computer of the Academy of Sciences of the USSR; new elements and units for computers; a method of control of the arithmetic unit; a method of electing the required word from the dictionary in machine translation; and present-day computer technology.

Controlled Thermonuclear Reactions

By Samuel Glasstone and Ralph H. Lovberg. 1960, D. Van Nostrand Co., Inc., Princeton, N. J. 523 p., $6^1/_4 \times 9^1/_4$ in., bound. $5.60. This is a survey of basic principles and current research into the production of controlled energy from nuclear fusion. Discussion of the physical conditions necessary for the possible methods of achieving fusion is followed by description of the properties, the techniques of studying the properties, and the methods of production of plasmas of thermonuclear interest. Research on the pinch effect, the Stellarator, magnetic mirror systems, the Astron concept, and other proposed methods for plasma heating and confinement is then reviewed, and the book concludes with a survey of sources of energy loss from heated plasmas and an outline of plasma stability theory.

Engineering Analysis

By Wen-Hsiung Li. 1960, Prentice-Hall, Inc., Englewood Cliffs, N. J. 362 p., $6^1/_4 \times 9^1/_4$ in., bound. $8.25. This is a treatment of mathematics entirely from the engineer's point of view. The topics covered are applications of integral and of differential calculus, vector algebra, ordinary differential equations, and the Fourier series. Numerical and graphic methods are given, emphasizing precision of results. Worked-out solutions are given for some problems, and answers are given for all.

Fabrication des Avions et Missiles

By M. P. Guibert. 1960, Dunod, Paris, France. 847 p., $7^1/_2 \times 11$ in., bound. No price given. The author, an executive with aeronautical firms in France including Nord-Aviation and Marcel Dessault, teaches at l'Ecole Nationale Supérieure de l'Aeronautique, Paris, where this book is the text for his course. It is a study of the principal activities in a concern which manufactures aircraft and missiles, from receipt of initiating order and preliminary research, planning, design, and formulation of tooling requirements, through all stages of fabrication including full description of tooling and alternative methods, to assembly and final finishing operations. The final chapters are devoted to special fabrication techniques and an evolutionary description of aviation materials and manufacturing tools, including the latest developments.

Finite-Difference Methods for Partial Differential Equations

By George E. Forsythe and Wolfgang R. Wasow. 1960, John Wiley & Sons, Inc., New York, N. Y. 444 p., $6 \times 9^1/_4$ in., bound. $11.50. This monograph is an account of many of the more important results and difference methods currently available in the rapidly developing field of the method of finite differences, the only numerical method universally applicable to the solution of both linear and nonlinear differential equations. It attempts to give a general knowledge of the theoretical background and the known methods, excluding topics having no direct bearing on numerical analysis, and not trying to provide a guide for programmers or to include many numerical examples. Readers will require knowledge of advanced calculus and the matrix theory, but not necessarily the theory of partial differential equations.

From Theory to Practice in Soil Mechanics: Selections From the Writing of Karl Terzaghi

By L. Bjerrum and others. 1960, John Wiley & Sons, Inc., New York, N. Y. 425 p., $8^3/_4 \times 11^1/_2$ in., bound. $12. A detailed account of the personality, professional achievements, and method of working of Karl Terzaghi, composed mainly of his own words through selection from his writings, with some explanatory comment. Clearly demonstrated in this manner is the way in which he established the fundamental principles of soil mechanics and then used them as powerful tools in his engineering practice. Also included is a bibliography, and contributions describing his life, achievements, and their significance.

Fundamentals of Signal Theory

By John L. Stewart. 1960, McGraw-Hill Book Company, Inc., New York, N. Y. 346 p., $6^1/_4 \times 9^1/_4$ in., bound. $9. This book is concerned with the mathematical concepts and techniques of value in the analysis of linear and time-variant physical systems. Extensive consideration is given the steady state interpreted through the pole-zero diagram in the first five chapters. Operational methods are introduced in chapter 6, and subsequently concepts in Laplace and Fourier transforms are considered with the aid of techniques of contour integration.

Handbook of Laplace Transformation

By Floyd E. Nixon. 1960, Prentice-Hall, Inc., Englewood Cliffs, N. J. 115 p., $5^1/_2 \times 8^1/_4$ in., bound. $6. The first two sections of this handbook deal with determinants, root-finding methods, and Routh's criterion. Section 3 contains the derivation of many Laplace transform theorems. Section 4 describes identities, section 5 illustrates by examples the use of the Laplace transform method, and the final section is an extensive table of Laplace transform pairs.

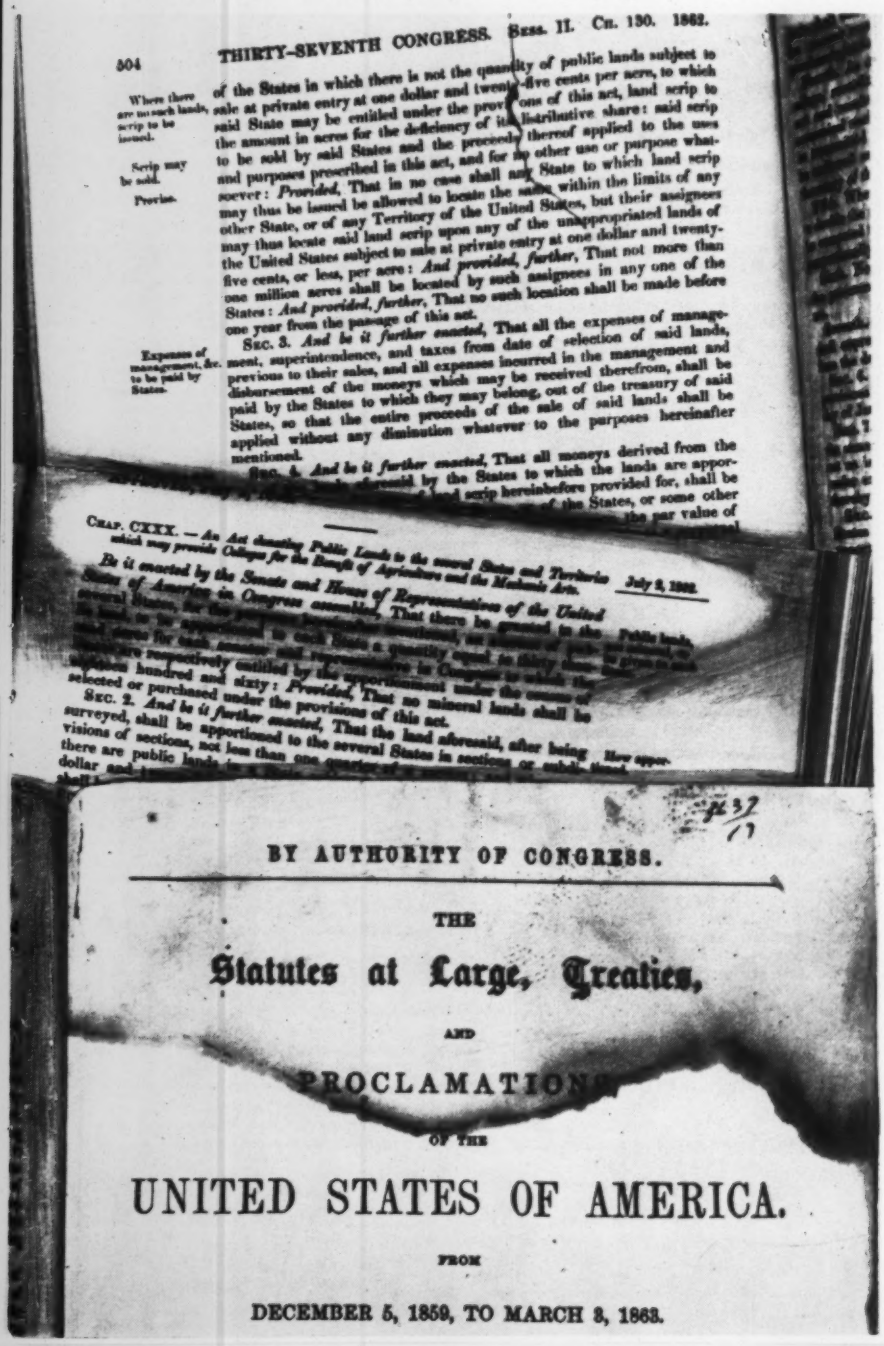
Notes on Society Activities and Events

E. S. NEWMAN
News Editor

THE ROUNDUP

Centennial of Land-Grant Education in the United States[1]

THE year of 1962 will be the One-Hundredth Anniversary of the Land-Grant Act in the United States and, in commemoration of this extremely important educational adventure, the American Association of Land-Grant Colleges and Universities will observe the anniversary through programs and activities of various kinds during the latter half of 1961 and throughout 1962. Richard A. Harvill, president of the University of Arizona, is Chairman of the Centennial Steering Committee of the Association.


504 THIRTY-SEVENTH CONGRESS. SESS. II. CH. 130. 1862.
Where there are no such lands, scrip to be issued.
Scrip may be sold.
Proviso.
of the States in which there is not the quantity of public lands subject to sale at private entry at one dollar and twenty-five cents per acre, to which said State may be entitled under the provisions of this act, land scrip to the amount in acres for the deficiency of its legislative share: said scrip to be sold by said States and the proceeds thereof applied to the uses and purposes prescribed in this act, and for no other use or purpose whatsoever: *Provided*, That in no case shall any State to which land scrip may thus be issued be allowed to locate the same within the limits of any other State, or of any Territory of the United States, but their assignees may thus locate said land scrip upon any of the unappropriated lands of the United States subject to sale at private entry at one dollar and twenty-five cents, or less, per acre: *And provided, further*, That not more than one million acres shall be located by such assignees in any one of the States: *And provided, further*, That no such location shall be made before one year from the passage of this act.
Expenses of management, &c. to be paid by States.
SEC. 3. *And be it further enacted*, That all the expenses of management, superintendence, and taxes from date of selection of said lands, previous to their sales, and all expenses incurred in the management and disbursement of the moneys which may be received therefrom, shall be paid by the States to which they may belong, out of the treasury of said States, so that the entire proceeds of the sale of said lands shall be applied without any diminution whatever to the purposes hereinafter mentioned.
SEC. 4. *And be it further enacted*, That all moneys derived from the
CHAP. CXXX. — An Act donating Public Lands to the several States and Territories which may provide Colleges for the Benefit of Agriculture and the Mechanic Arts. July 2, 1862.
Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there be granted to the
BY AUTHORITY OF CONGRESS.
THE
Statutes at Large, Treaties,
AND
PROCLAMATIONS
OF THE
UNITED STATES OF AMERICA.
FROM
DECEMBER 5, 1859, TO MARCH 3, 1863.

The Land-Grant Act, or as it is called sometimes, "The Morrill Act," was initiated by Congressional action in 1862 during the turmoil of the Civil War and was signed into law by President Lincoln on July 2, 1862. Its purpose was to provide for "the endowment, support, and maintenance of at least one college (in each state) where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." To accomplish this purpose under the specific terms of the act, each state received a grant of Federal land apportioned on the basis of 30,000 acres for each member of Congress. Thus a system of education was established whereby important changes were achieved in education in the United States.

How It All Started. The Land-Grant movement was not begun primarily by educators, but by hard-headed, practical people who wanted service that the then-existing colleges and universities did not render. Early private colleges in the United States served a relatively small group, like those who wanted to be lawyers, physicians, ministers, and teachers, and those who wished to enjoy more abundantly the life of cultural ease.

Hence the Land-Grant Act was an innovation whereby the advantages of higher education would be placed within the reach of all Americans. It undertook to do this by giving Federal land to the states of the Union, so that their universities and colleges could be endowed with sufficient capital to develop the technolo-

[1] By J. D. Forrester, Dean, College of Mines, University of Arizona, Tucson, Ariz.

gies of subject fields, such as those of agriculture, engineering, and science.

Although at least three men, namely: Jonathan B. Turner, Thomas G. Clemson, and Justin S. Morrill, in addition to President Lincoln, played roles in the development of what eventually became known as the Land-Grant Act, its leading proponent and most vigorous advocate was Morrill of Vermont.

Benefits Accrue. The pronounced benefits of the original Land-Grant Act have been improved and sustained by several constructive legislative amendments and by continued financial support. Also, consistent implementation of the principles of the movement has been accomplished largely through the interests given to it officially since 1885 by the American Association of Land-Grant Colleges and Universities.

Land-Grant Institutions. Dispersed throughout the United States, today Land-Grant institutions number 68. These educate approximately one out of every five students enrolled in all the colleges in the Nation. Although Land-Grant schools comprise only 5 per cent of all colleges in the United States, they enroll more than 20 per cent of the students; they grant more than 40 per cent of all doctoral degrees; they confer approximately 50 per cent of the doctorates in science, engineering, and the health professions, and virtually all degrees in agriculture, as well as 25 per cent of the degrees in the arts, languages, business and commerce, and in the field of teacher preparation. The Land-Grant colleges conduct the world's largest off-campus educational programs and they have pioneered in research and the advancement of science and industrial technologies, and therefore, as a group, they have been major factors in causing the high rate of productivity in the United States. The Land-Grant schools furnish nearly half of the Nation's reserve officers for military service and, in so doing, they are recognized as the bulwarks of the civilian-military relationship in our democracy.

The curriculums in these colleges constitute a virtual spectrum of learning and the measurable benefits in dollars and cents to the American people of the instruction and research done in Land-Grant schools annually exceed by many times the total amount expended on these institutions.

Anniversaries—A Time for Assessment. Anniversaries are events when we can note achievements of the past and, also, they are occasions when we should assess the portents of the future. Therefore the American Association of Land-Grant Colleges and Universities is not proposing to observe the One-Hundred Anniversary Year only by complacently spending time in analyzing the past accomplishments. It will devote much of its interests to intensive studies of ways and means whereby higher education can meet its future responsibilities and opportunities. These will be carried on in a systematic way both on a national level and by individual programs in each state.

The purposes of the centennial may be summed up briefly as follows:

1 To build public understanding of the Land-Grant college and university movement, especially as this may contribute to solving present problems and meeting future needs of the whole of American higher education.

2 To assess and evaluate the work the Land-Grant institutions are now doing toward the end that they may identify more clearly their special responsibility to the American people and the world during their second century of service.

It is wholly fitting that we review here these matters as they obtain to mechanical engineering and to the engineering profession, in general. This is because the goals set by the Land-Grant Association have particular significance to the maintenance of all phases of engineering education in the United States. That is, only through the channels of learning which are, and will be, available in Land-Grant schools will it be possible to train the sufficient engineers who will be needed to advance the welfare of the United States during the future when applied science and engineering undoubtedly will continue to play ever-increasing roles in sustaining the development of our American civilization.

It is recommended, therefore, that members of the mechanical-engineering profession, as well as all engineers, support the purposes and objectives to which the Centennial is dedicated.

Engineering and Education

ENGINEERING is a profession. Its members do creative work which results in things that people need or want. These things may be highways, submarines, interplanetary vehicles, antibiotics, or television. Science, on the other hand, is a search for knowledge. The science of mathematics extends abstract knowledge. The science of physics extends organized knowledge of the physical world. In each of these consideration can be limited to a carefully isolated aspect of reality.

The engineer must deal with reality in all its aspects. He must not only be competent to use the most classical and the most modern parts of science, but he must be able to devise and make a product which will be used by people. Moreover, he must assume professional responsibility in so far as the safety and well-being of people are affected by the thing he makes.

A sound program which majors in engineering or one of its branches—civil, mechanical, chemical, etc.—will be the most stimulating and rewarding undergraduate experience for the great majority of candidates for engineering. They will find in it not only the science of the modern physicist, but also the other kinds of science—for example, fluid mechanics, or electric-circuit theory—which the engineer uses and develops as incisive means for resolving the complex problems of the real world. Such a program grows out of an educational environment created by men in contact with the world of people and industry which serves the people. It will include attention to the furtherance of many parts of science which are of special interest to the engineer.

Engineering education is being urgently called upon to produce graduates well versed in rapidly advancing science who will lead industry and the public into the new world which engineering will make possible. Engineers will often discover in science through their own research and invention or through the findings of scientists those things which can be put to human use. In any engineering achievement, however, the thing produced is the objective, and all means available to the intellect of man will be employed to reach that objective. Science and its application remain a part, but only a part, of any great engineering advance. Supersonic aircraft could have been devised and made only by engineers with great resources in science. In order to make the first supersonic airplane, however, science had to be combined with the engineer's drive toward creation of a predetermined object. Young people who can respond to this kind of challenge are needed now, but they will be needed as never before in the years ahead.—*C. S. Draper*, Fellow ASME; *J. H. Keenan*, Fellow ASME; *T. K. Sherwood*, Mem. ASME; and *J. B. Wilbur*.

This Statement was prepared by a Committee of the School of Engineering, Massachusetts Institute of Technology, March, 1961.

MEETINGS OF OTHER SOCIETIES

• IN THE UNITED STATES

May 11

Air Force Office of Scientific Research (AFOSR), lecture and banquet in honor of the 80th anniversary of Theodore von Karman, Mem. ASME, managed by the Institute of the Aerospace Sciences, Sheraton Park Hotel, Washington, D. C.

May 15–16

Society of American Military Engineers, annual meeting, Mayflower Hotel, Washington, D. C.

May 15–17

National Academy of Sciences, spring conference, Shoreham Hotel, Washington, D. C.

May 22–24

National Telemetering Conference, sponsored by ISA, AIEE, the American Rocket Society, IRE, and the Institute of the Aerospace Sciences, Hotel Morrison, Chicago, Ill.

May 22–24

American Society for Quality Control, annual convention and exhibition, Sheraton Hotel, Philadelphia, Pa.

May 22–26

American Society of Tool and Manufacturing Engineers, annual engineering conference and exposition, Statler Hotel and the New York Coliseum, New York, N. Y.

May 25–26

American Institute of Mining, Metallurgical and Petroleum Engineers, annual Rocky Mountain petroleum sections joint meeting, Salt Lake City, Utah

May 25–26

Operations Research Society of America, meeting, Sheraton-Blackstone Hotel, Chicago, Ill.

June 1–2

ASA, 15th annual spring meeting of the Company Member Conference, Pick-Congress Hotel, Chicago, Ill.

June 4–8

American Nuclear Society, annual meeting, Penn-Sheraton Hotel, Pittsburgh, Pa.

June 4–9

American Water Works Association, annual conference, Municipal Auditorium, Detroit, Mich.

June 4–9

SAE, summer meeting, Chase-Park Plaza Hotel, St. Louis, Mo.

June 5–7

Edison Electric Institute, annual convention, Waldorf-Astoria Hotel, New York, N. Y.

June 5–9

Society of the Plastics Industry, national plastics exposition and conference, Commodore Hotel and New York Coliseum, New York, N. Y.

June 11–15

Air Pollution Control Association, annual meeting, Hotel Commodore, New York, N. Y. Air Pollution Instrumentation Symposium, June 12 (ISA and APCA)

June 12–16

Ninth Annual Technical Writers' Institute, Rensselaer Polytechnic Institute, Troy, N. Y.

June 13–16

IAS/ARS joint mid-year meeting, Ambassador Hotel, Los Angeles, Calif.

• IN EUROPE

May 15–19

The Institute of Fuel, conference on waste heat recovery from industrial furnaces, Bournemouth, England

June 9–17

European Convention of Chemical Engineering and ACHEMA 1961, Frankfurt am Main, Germany

June 20–24

Fourth International Powder Metallurgy Congress, Reutte, Tyrol, Austria

June 26–July 1

Second International Measurement Conference (IMEKO), Engineering Societies Building, and separately organized international measurement conference, Budapest, Hungary

July 30–August 6

International Symposium on the Durability of Concrete, prepared by the Czechoslovak Academy of Sciences, Institute of Theoretical and Applied Mechanics, within the framework of The Permanent Committee of Réunion Internationale des Laboratoires d'Essais et de Recherches sur les Matériaux et les Constructions (RILEM); to be held in Prague.

August 21–31

United Nations Conference on New Sources of Energy; and an industrial-commercial exhibition of equipment showing developments in solar, wind, and geothermal energy fields, organized by Rassegna Internazionale Elettronica, both in Rome, Italy

August 23–26

Institute of Management Sciences, eighth annual international meeting, Palais des Congres, Brussels, Belgium

November 16–25

Hungarian Scientific Society for Mechanical Engineering, international festival of scientific and technical films for mechanical engineering, Budapest, Hungary

• IN CANADA

April 17–19

Canadian Institute of Mining and Metallurgy, annual meeting, Chateau Frontenac Hotel, Quebec City, Que.

June 6–8

ISA, summer instrument-automation conference, Royal York Hotel and Queen Elizabeth Hall, Toronto, Ont.

October 19–November 7

The Iron and Steel Institute, special meeting in the U. S. and Canada

• IN JAPAN

November 6–11

Society of Chemical Engineers, Japan, 25th anniversary congress exhibition, Sankei Hall, Tokyo, Japan

(For ASME Coming Events, see page 142.)

PEOPLE

Man of The Year. STEPHEN D. MOXLEY, Fellow ASME, president of American Cast Iron and Pipe Company, has been chosen the Man of the Year for 1960 in Birmingham, Ala. He also was voted one of four of the most outstanding men of Birmingham for all time in the 1960 Metropolitan Audit, conducted by the Southern Institute of Management.

Man of Several Terms. RAYMOND R. TUCKER, Fellow ASME, has been re-elected to a third term as mayor of St. Louis, Mo., winning by a resounding margin over his Republican opponent. With an unusually heavy voter turnout, Mr. Tucker led by 67,440 to 39,837.

Honors and Awards. THEODORE VON KARMAN, Mem. ASME, has been named by The Institution of Mechanical Engineers to receive the 1961 James Watt International Medal for his important contributions to the advancement of mechanical engineering science, particularly in the field of aeronautics. Dr. von Karman's nomination for the award was sponsored by ASME, which honored him in 1941 with the ASME Medal, and in 1958 with the Timoshenko Medal. He will receive the James Watt Medal at an institution meeting later in the year.

GORDON B. CARSON, Mem. ASME, received the highest citation of the Ohio Society of Professional Engineers on March 18 at the society's convention in Dayton, Ohio. He was cited for his untiring efforts to promote the professional welfare of the engineer, his eminence as an educator and administrator in engineering, and his leadership as an engineer in public service. He is vice-president of business and finance and professional industrial engineering at Ohio State University.

WILLIAM V. KÄHLER, president of the Illinois Bell Telephone Company, Chicago, received the 1960 Washington Award March 2, 1961, at a dinner in Chicago, Ill.

United Engineering Center

Columbus Over the Top

THE Columbus Section affirms its belief in ASME. By action of its Executive Committee it pledged $1355 to the UEC, the amount necessary to meet its quota. One third was paid with the pledge, the balance will be earned and paid by the Section from its local activities. Our hat's off to Columbus and welcome to the 100 per cent club.

We know that other Sections have made contributions, but to the best of our knowledge this is the first of its kind at this critical period in our campaign. Eighteen Sections are less than $1000 short of their quota. Nineteen have achieved 80 per cent or better. The Columbus action could well be reviewed by all of them.

Forty-seven Sections improved their position in March. How about the other 52? We need help from everybody to finish this job.

Greenville continues to show good improvement, and Piedmont-Carolina tops the 90 per cent mark. Not much question that both will reach 100 per cent shortly. Will Greenville, with $402 to go, make the grade ahead of its neighbor with $468 to go?

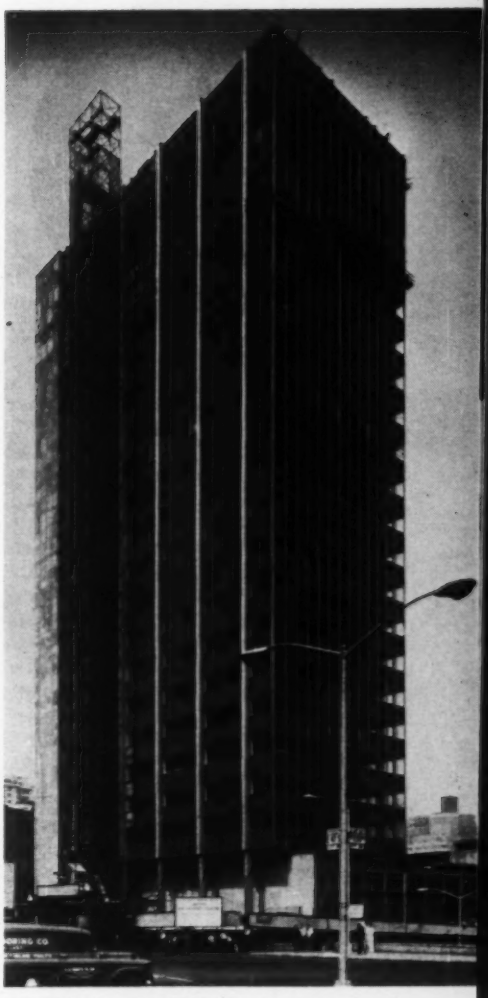
New London jumped its achievement 13.6 per cent and its member participation by 5 per cent. Gulf Coast reached 90 per cent of quota and increased member participation by 11 per cent. Shows what can be done when you contact the individual member. Excellent showing in both cases.

St. Louis turned in a fine contribution from local industry. It is now just $387 short of its goal. If this Section can boost its member participation well above the present 30.6 per cent, achievement of its quota would be almost automatic. How about a little work with the local Section members to help close this gap?

Last December, somebody canceled a $10 pledge made through the Fort Wayne Section. This action dropped them $9 below 100 per cent quota. Does no one in Fort Wayne have another $10 pledge? Make it $25, to put this Section back over the top. It was a year ago this April that the last pledge was received from here. Where is Operation Second Wind? Get back that $10, and ninety more to keep it company.

North East Florida has been coming along well lately. We can look for action in Washington, D. C., shortly, and Syracuse should make good progress this spring. Northern New England is stirring now that the snow and ice have gone.

$40,000 to go. With everybody behind the effort, we can make it an easy job.



United Engineering Center is fast reaching completion. Early in April it looks like this.

ASME Member Gifts Campaign as of March 31, 1961

In Order of Quota Deficit in Dollars

Fort Wayne	9
No. Ala.-Miss.	100
Cleveland	185
Gulf Coast	186
New London	289
St. Louis	387
Greenville	402
Mid-Hudson	463
Piedmont-Carolina	468
Rock River Valley	499
Nebraska	508
Milwaukee	594
Iowa-Illinois	655
Miami	752
Central Kansas	853
Paducah	860
C.S.R.A.	963
Utah	972
More Than a $1,000	
Minnesota	1,005
Rochester	1,007
Idaho-Montana	1,067
Palm Beach	1,090
Central Michigan	1,119
E. Virginia	1,152
N. E. Florida	1,155
Kansas City	1,165
Susquehanna	1,223
Savannah	1,324
Mexico	1,336
Syracuse	1,400
Mohawk Valley	1,403
Toledo	1,404
Pittsburgh	1,544
Akron	1,626
New Haven	1,743
Oregon	1,790
Delaware	1,843
Arizona	1,944
More Than $2,000	
E. Tennessee	2,053
Central Pa.	2,125
W. Mass.	2,296
E. No. Carolina	2,311
Central Illinois	2,557
Central Va.	2,581
Arklatex	2,622
New Mexico	2,776
Louisville	2,800
Virginia	2,893
Florida	2,969
St. Joseph Valley	3,039
W. Washington	3,297
No. New England	3,700
Mid-Continent	3,975
Chattanooga	4,239
Baltimore	4,264
Buffalo	4,780
Rocky Mountain	4,839
New Orleans	6,170
Hartford	6,895
Chicago	6,911
Ontario	6,916
Mid-Jersey	7,583
Boston	7,881
So. Texas	8,720
No. Texas	9,235
Washington	9,430
More Than $10,000	
San Francisco	14,060
Philadelphia	18,704
Los Angeles	35,467

Current Engineering, Events, News, and Comment

E. S. NEWMAN
News Editor

THE ASME NEWS

ASME Summer Annual Meeting Offers a Vigorous Study and Pleasure Program

THE Los Angeles Section of the ASME will be the Host Section to the 1961 Summer Annual Meeting, June 11–14, at the Statler Hilton Hotel, Los Angeles, Calif.

Technical Program Covers Many Fields. An interesting and informative technical program will cover the varied fields of mechanical engineering. Thirty-six sessions, including panel discussions, are being sponsored by 13 Professional Divisions and Groups. Subjects: Automatic control, fuels, heat transfer, human factors, machine design, management, materials handling, nuclear engineering, petroleum, process industries, production engineering, safety, and solar energy will have comprehensive coverage. Two sessions will be devoted to the Student Member Competition at which the winners from the 12 Regional Student Conferences will present their papers before the Society's members and guests.

Feature Events. To encourage fellowship and the renewal of acquaintanceships, the Los Angeles Section will host an "Early Bird" Reception Sunday afternoon.

The President's Luncheon on Monday will be highlighted by an address by ASME President William H. Byrne.

The Summer Annual Business Meeting of the Society will be held, as usual, at 4:45 p.m. on Monday and all members are urged to attend. Buses will leave from the Statler Hilton at 6:30 p.m., Monday for a tour of Disneyland.

The Management Luncheon on Tuesday will feature an address by Dean Darrell Holmes of San Diego State College. His talk will be "Fitting Round Pegs Into Square Holes." Tuesday evening's agenda consists of the Social Hour, sponsored by the Los Angeles Section, followed by the Summer Annual Banquet.

Details on the inspection trips and the activities planned for the women will be found in the body of the program which follows.

SUMMER ANNUAL BANQUET

B TUESDAY, JUNE 13 7:00 p.m.

PRESIDENT'S LUNCHEON

L MONDAY, JUNE 12 12:15 p.m.

Address by: *William H. Byrne*, President, ASME

AUTOMATIC CONTROL SESSION

MONDAY, JUNE 12 9:30 a.m.

Operations Research Study of Steam-Power Plant Automation,[1] by *J. K. Dillard*, Westinghouse Elec. Corp., and *J. L. Everett, III*, Philadelphia Elec. Co.

Aspects of Power-Plant Automation,[1] by *Menachem Birnbaum*, Westinghouse Elec. Corp., *George Kotnick*, Philadelphia Elec. Co., and *D. M. Sauter*, Westinghouse Elec. Corp.

Dynamic Representation of a Large Boiler-Turbine Unit,[1] by *J. H. Daniels*, Philadelphia Elec. Co., *Mark Enns*, Westinghouse Elec. Corp., and *R. D. Hottenstine*, Combustion Engrg., Inc.

Field Testing to Verify a Dynamic Model,[1] by *H. G. Dallas*, Philadelphia Elec. Co., and *D. M. Sauter*, Westinghouse Elec. Corp.

FUELS SESSIONS

1 WEDNESDAY, JUNE 14 9:30 a.m.

Porous Media Combustion,[1] by *R. T. Ellington*, Inst. of Gas Tech.

[1] Paper not available—see box on this page.

Development of a Combination Liquid and Gas-Fuel Burner System for Thermoelectric Generators,[1] by *Larry Selwitz*, Westinghouse Elec. Corp.

Flame Stabilization in a Boundary Layer Over a Cooled Surface,[1] by *R. J. Heinsohn* and *J. E. Lay*, Michigan State Univ.

2 WEDNESDAY, JUNE 14 2:30 p.m.

Application of Burner Safety Supervise Controls to Existing Gas-Fired Central Station Boilers,[1] by *C. J. Henne*, City Public Service Board, San Antonio, Texas

The Use of Natural Gas in Open Hearths,[1] by *E. R. Gardner*, The Ohio Valley Gas Co.

HEAT TRANSFER SESSIONS

1 MONDAY, JUNE 12 9:30 a.m.

Panel Discussion: Status on Energy Conversion

Photovoltaic Effects,[2] by *P. A. Iles*, Hoffman Electronics Corp.

[2] Not to be printed.

Availability of Papers

ONLY numbered ASME papers in this program will be available in advance of the meeting. Most papers will be available at the meeting and in separate copy form until April 1, 1962. The final listing of available technical papers will be found in the issue of MECHANICAL ENGINEERING which contains an account of the meeting. Prices are 50 cents to members of ASME; $1 to nonmembers, plus postage and handling charges. Payment also may be made by free coupons, or coupons which may be purchased from the Society in lots of ten at $4 to members; $8 to nonmembers. **You can save the postage and handling charges by including your check or money order and sending both to: ASME Order Department, 29 West 39th Street, New York 18, N.Y.** Papers must be ordered by the paper numbers listed in this program, otherwise the order will be returned.

Fuel Cells,[1] by *George Evans*, Nat'l Carbon Co.

Magnetohydrodynamic Electrical Power Generators,[2] by *M. E. Talaat*, The Martin Co.

Thermoelectrics,[2] by *P. Miller*, Gen. Atomics, Div. of Gen. Dynamics Corp.

Thermionic Emission,[2] by *R. Pidd*, Gen. Atomics Div. of Gen. Dynamics Corp.

2 MONDAY, JUNE 12 2:30 p.m.

Thermal Radiation Characteristics of Cylindrical Enclosures, by *E. M. Sparrow*, Univ. of Minnesota, *L. U. Albers*, NASA, Lewis Res. Center, and *E. R. G. Eckert*, Univ. of Minnesota. (Paper No. 61—SA-23)

Techniques for Optimization of a Finned-Tube Radiator, by *L. H. Schreiber, R. P. Mitchell, G. D. Gillespie*, and *T. M. Olcott*, Convair, Div. of Gen. Dynamics Corp. (Paper No. 61—SA-44)

Heat Transfer by Simultaneous Conduction and Radiation in an Absorbing Medium, by *Raymond Viskanta*, Argonne Nat. Lab., and *R. J. Grosh*, Purdue Univ. (Paper No. 61—SA-34)

3 TUESDAY, JUNE 13 9:30 a.m.

Heat Transfer for Pulsating Laminar Duct Flow, by *Robert Siegel* and *M. Perlmutter*, NASA, Lewis Research Center. (Paper No. 61—SA-28)

Measurements of Diabatic Flow in an Annulus With an Inner Rotating Cylinder, by *K. M. Becker*, Swedish AEC, Stockholm, Sweden, and *Joseph Kaye*, M.I.T. (Paper No. 61—SA-19)

The Influence of a Radial Temperature Gradient on the Instability of Fluid Flow in an Annulus With an Inner Rotating Cylinder, by *K. M. Becker*, Swedish AEC, Stockholm, Sweden, and *Joseph Kaye*, M.I.T. (Paper No. 61—SA-20)

Forced Convection Heat Transfer From a Uniformly Heated Sphere, by *W. S. Brown*, Utah R&D Co., *C. C. Pitts* and *George Leppert*, Stanford Univ. (Paper No. 61—SA-26)

4 TUESDAY, JUNE 13 2:30 p.m.

Laminar Flow Heat Transfer for Variable Physical Properties, by *L. B. Koppel*, California Inst. of Tech., and *J. M. Smith*, Northwestern Univ. (Paper No. 61—SA-32)

Analysis of Film Boiling on Vertical Surfaces, by *J. C. Y. Koh*, Boeing Airplane Co. (Paper No. 61—SA-31)

The Effect of Subcooled Liquid on Laminar Film Boiling, by *E. M. Sparrow*, Univ. of Minnesota, and *R. D. Cess*, North Carolina State Coll. (Paper No. 61—SA-29)

Entrance Effects in a Two-Phase Slug Flow, by *Raphael Moissis* and *Peter Griffith*, M.I.T. (Paper No. 61—SA-30)

5 WEDNESDAY, JUNE 14 9:30 a.m.

Transient, Laminar, Combined Free and Forced Convection in a Duct, by *W. K. Mueller*, New York Univ., and *S. L. Zeiberg*, City Coll. of New York. (Paper No. 61—SA-25)

The Development of Free Convection Between Heated Vertical Plates, by *J. R. Bodoia*, Westinghouse Elec. Corp., and *Fletcher Osterle*, Carnegie Inst. of Tech. (Paper No. 61—SA-33)

Velocity and Temperature Profiles in Turbulent Boundary Layers With Tangential Injection, by *R. A. Seban* and *L. H. Back*, Univ. of California. (Paper No. 61—SA-24)

Thermocouple Temperature Disturbances in Low Conductivity Materials, by *J. V. Beck*, AVCO Corp. (Paper No. 61—SA-27)

HUMAN FACTORS SESSIONS

1 MONDAY, JUNE 12 9:30 a.m.

Jointly With Human Factors Society

Allocation of Functions Between Man and Machine in Automated Systems,[1] by *Nehemiah Jordan*, Rand Corp.

The Role of Simulation in the Design of Man-Machine Systems,[1] by *H. L. Wolbers, Jr.*, Douglas Aircraft Co., Inc.

Man-Machine Steering Dynamics,[1] by *J. G. Wohl*, Dunlap & Assoc., Inc.

2 MONDAY, JUNE 12 2:30 p.m.

Jointly With Human Factors Society

The Life Sciences as a Base for Engineering Instruction and Practice Paralleling the Physical Sciences,[1] by *L. M. K. Boelter*, Univ. of California

[1] Paper not available—see box on page 126.
[2] Not to be printed.

Registration Schedule

Sunday, June 11	3:00 p.m. to 6:00 p.m.
Monday, June 12	8:00 a.m. to 3:00 p.m.
Tuesday, June 13	8:00 a.m. to 3:00 p.m.
Wednesday, June 14	8:00 a.m. to 12:00 noon

Human Factor Standards in Engineering Design,[1] by *E. J. Merrick*, Gen. Elec. Co.

Human Factors in Mechanical Design of Dental Operating-Room Equipment,[1] by *S. S. Golden*, USC, School of Dentistry; Dental Equipment Mfgrs.

MACHINE DESIGN SESSIONS

MONDAY, JUNE 12 9:30 a.m.

Jointly With Production Engineering

See Production Engineering 1

MONDAY, JUNE 12 2:30 p.m.

Jointly With Production Engineering

See Production Engineering 2

1 WEDNESDAY, JUNE 14 9:30 a.m.

The Superposition of Stress Concentration Factors, by *F. W. Paul, Jr.*, Mixing Equipment Co., Inc., and *T. R. Faucett*, Univ. of Missouri, School of Mines & Metallurgy. (Paper No. 61—SA-5)

Thermal Stresses in Spherical Case-Bonded Propellent Grains, by *B. W. Shaffer*, New York Univ., and *Irvin Krause*, American-Standard. (Paper No. 61—SA-15)

Zero-Shift in Galvanometers Subjected to Mechanical Vibrations,[1] by *D. A. Conrad*, Inst. of Tech. of Darmstadt, Inst. for Applied Mech., Darmstadt, Germany, and *D. G. Shellhorn*, Hughes Aircraft Co.

Surface Durability Ratings of Spiroid Gears, by *W. D. Nelson*, Illinois Tool Works. (Paper No. 61—SA-1)

Maximum Stresses in Beams and Plates Vibrating at Resonance,[2] by *E. E. Ungar*, Bolt Beranek & Newman, Inc. (Paper No. 61—SA-14)

4 WEDNESDAY, JUNE 14 2:30 p.m.

Constant Diameter Cams, Their Properties and Design Characteristics, by *Karl Brunell*, Bell & Howell Co. (Paper No. 61—SA-2)

On the Variety of Motions Generated by Mechanisms, by *Ferdinand Freudenstein*, Columbia Univ. (Paper No. 61—SA-3)

Synthesis of Rectilinear Motion by Mechanical Harmonic Function Generators, by *B. W. Shaffer*, New York Univ., and *Irvin Krause*, American-Standard. (Paper No. 61—SA-4)

On the Kinematics of Rubber-Covered Cylinders Rolling on a Hard Surface,[1,2] by *G. N. Sandor*, Huck Co., Consulting Engrs.

MANAGEMENT SESSIONS

1 TUESDAY, JUNE 13 9:30 a.m.

A Philosophy of Management,[1] by *W. E. Johnson*, Gen. Elec. Co.

Engineering Malpractice,[1] by *I. L. Tunis*, attorney-at-law and consulting engineer, New Orleans, La.

TUESDAY, JUNE 13 9:30 a.m.

Jointly With Safety

See Safety 3

L TUESDAY, JUNE 13 12:15 p.m.

Management Luncheon

Presider: *Marshall Anderson*, Gen. Elec. Co., Bloomington, Ill.

Speaker: *Darrell Holmes*, San Diego State Coll., San Diego, Calif.

Subject: **Fitting Round Pegs Into Square Holes**

[2] Not presented orally.

2 TUESDAY, JUNE 13 2:30 p.m.

Selling Engineering to Management,[1] by *D. E. Farr*, H. B. Maynard & Co., Inc.

Imagination in Managment,[1] by *A. L. Logan*, California Investors, Inc.

Planning in a Specialty Business,[1] by *George Gregory*, Products Research Co.

3 WEDNESDAY, JUNE 14 9:30 a.m.

The Factors Behind Business Success,[2] by *C. W. Randle*, Booz, Allen & Hamilton

Critical Path Scheduling,[1] by *A. W. Barkson*, IBM

The Influence of Development Objectives Upon Production Costs,[1] by *D. K. Richardson*, Hughes Aircraft Co.

MATERIALS HANDLING SESSIONS

1 WEDNESDAY, JUNE 14 9:30 a.m.

A One-Man Boom-Hoist System for Handling Citrus Fruit, by *R. J. Smith* and *R. L. Perry*, Univ. of California. (Paper No. 61—SA-10)

Pitfalls in Air Conveying, by *D. L. Burrell*, U. S. Industrial Chemicals Co. (Paper No. 61—SA-9)

Tensions in Straight and Curvilinear Belt Conveyers, by *W. A. Winkler*, Utah Construction & Mining Co. (Paper No. 61—SA-11)

2 WEDNESDAY, JUNE 14 2:30 p.m.

The Development of Protective Handling Systems for High-Reliability Components and Systems, by *G. A. Peters*, Autonetics. (Paper No. 61—SA-16)

The Automation of a 40,000 Ton Per Day Ore-Handling Facility, by *C. M. Marquardt*, Industrial Physics & Electronics Co. (Paper No. 61—SA-8)

NUCLEAR ENGINEERING SESSIONS

MONDAY, JUNE 12 2:30 p.m.

Jointly With Safety

See Safety 2

1 TUESDAY, JUNE 13 9:30 a.m.

Compact Power

Compact Mobile Nuclear Power Plants,[1] by *A. Stathoplos*, Nuclear Dev. Corp. of America, and *A. B. Rosenthal*, Gen. Motors Corp.

Compact Reactor Development for Ground Nuclear Power Applications, by *M. A. Rosen, T. W. McIntosh*, and *R. A. Du Val*, AEC. (Paper No. 61—SA-42)

The ML-1 Mobile Nuclear Power Plant, by *R. K. Swain, S. A. Varga*, and *J. C. Whipple*, Aerojet-General Corp. (Paper No. 61—SA-43)

Summary of SNAP Nuclear Power Systems,[1] by *E. B. Baumeister*, Atomics International

2 TUESDAY, JUNE 13 2:30 p.m.

Reactor Power Equipment

Design of Reliable and Economical Heat Exchangers for High-Temperature Sodium Service, by *R. D. Seifert* and *L. E. Phillips*, Alco Products, Inc. (Paper No. 61—SA-41)

Testing of a 3000-Kw (th) Liquid-Metal Model Steam Generator, by *L. J. Webster, D. E. Fletchall*, and *Douglas Logan*, Atomics International. (Paper No. 61—SA-46)

Design and Testing of Sodium Pumps for the Hallam Nuclear Power Facility, by *R. E. Ball* and *D. E. Cullman*, Borg-Warner Corp., and *R. W. Artz*, North American Aviation, Inc. (Paper No. 61—SA-39)

Erection and Precritical Testing of the *N. S. Savannah* Power Plant,[1] by *C. W. Hasek, Jr.*, The Babcock & Wilcox Co.

Revision of Constitution, By-Laws, and Rules

To: Members of the ASME

UPON authorization of the Council a few years ago, a subcommittee of the Constitution and By-Laws Committee was appointed "to consider and prepare a general revision of the Constitution, By-Laws, and Rules." Messrs. G. M. Muschamp, *Chairman*, L. E. Herbert and L. C. Smith who comprise the subcommittee, worked on the revision for more than two years and it is now ready for submission to the Council for action at its meeting in Los Angeles, Calif., June 11–12, 1961.

No substantive changes have been made but inconsistencies and duplications have been eliminated and, in particular, the form and arrangement of the matter have been revised.

On the assumption that the Council will make no changes in the revision, there will be a presentation at the Business Meeting in Los Angeles, June 12, 1961, by the Constitution and By-Laws Committee of proposed transposition of 14 Constitution items to By-Law status and the transposition of six By-Law items to Constitution status. Copies of these items will be available at the Business Meeting. After discussion and possible modification at the Business Meeting these items will be mailed, about Aug. 15, 1961, to the membership for letter-ballot action.

A limited number of copies of the 40-page revision is available upon request from the Secretary's office.

PETROLEUM SESSIONS

1 MONDAY, JUNE 12 2:30 p.m.

New Fabricating Techniques

Press Forming and Welding of Heavy Magnesium Plate, by *R. A. Matuszeski* and *A. J. Kish*, ACF Industries, Inc. (Paper No. 61—SA-18)

Electron Beam Welding,[1] by *H. A. James*, Sciaky Brothers

2 TUESDAY, JUNE 13 9:30 a.m

Fabrication Requirements for Balanced Classes of Piping,[1] by *H. S. Peterson* and *C. H. Voelker*, The M. W. Kellogg Co.

A Comparison of United States, European, and British Commonwealth Codes for the Construction of Welded Boilers and Pressure Vessels, by *J. F. Lancaster*, Kellogg International Corp., London, England (Paper No. 61—SA-10)

3 TUESDAY, JUNE 13 2:30 p.m.

Protection of Cooling Water Piping Systems Against Seawater Corrosion, by *Jan Goudriaan*, Asiatic Petroleum Corp. (Paper No. 61—SA-36)

A New Look at Pressure-Vessel Testing,[1] by *C. E. Lautzenheiser* and *F. B. Crouch, Jr.*, The Dow Chemical Co.

Use of Hard Carbide Components in Petrochemical Processing,[1] by *W. L. Kennicott*, Kennametal, Inc.

4 WEDNESDAY, JUNE 14 9:30 a.m.

A New Approach to Digital Computer Solution of Gas Networks Based on Kirchhoff's First Law, by *M. A. Dengler* and *J. P. Siken*, Arizona Public Service Co. (Paper No. 61—SA-13)

Simulation of the Gas-Transmission Industry, by *Edward Gordon*, United Gas Corp. (Paper No. 61—SA-12)

5 WEDNESDAY, JUNE 14 2:30 p.m.

Hydrodynamic Drag at Supercritical Reynolds Numbers,[1] by *Randolph Blumberg* and *A. M. Rigg*, Humble Oil & Refining Co.

Effect of Prestrain on the Fatigue Properties of Steel, by *J. F. Gormley*, Reed Roller Bit Co. (Paper No. 61—SA-17)

Engineering Considerations in Drilling From a Floating Vessel,[1] by *R. F. Bauer*, Global Marine Exploration Co.

PROCESS INDUSTRIES SESSIONS

1 MONDAY, JUNE 12 9:30 a.m.

Process Thermodynamics

An Axial-Flow Porous Plug Apparatus, by *R. C. King*, New York Univ., and *J. H. Potter*, Stevens Inst. of Tech. (Paper No. 61—SA-22)

Cyclic Processes in Closed Regenerative Thermal Machines, by *T. Finkelstein*, Battelle Memorial Inst. (Paper No. 61—SA-21)

2 MONDAY, JUNE 12 2:30 p.m.

Separation

Inertial Impaction in Cyclone Separators, by *M. H. Binark*, Technical Univ. of Istanbul Taksim, Turkey, and *S. P. Patel*, Pennsylvania State Univ. (Paper No. 61—SA-35)

Saturated Steam Reheater Applied in New Nuclear Power Station,[1] by *F. W. Gettler* and *J. H. Potter*, Stevens Inst. of Tech.

Official Notice
ASME Business Meeting

MONDAY, JUNE 12 4:45 p.m.

Presiding: *William H. Byrne*, President, ASME

Announcement of Location of 1962 Summer Annual Meeting

Election of Nominating Committee for 1962–1963

Amendments to Constitution and By-Laws as a Result of the Revision of the Constitution, By-Laws, and Rules

Report on United Engineering Center

Report on Unity of the Profession

This Business Meeting of the members provides an opportunity for a free discussion of Society policies and procedures. All members are urged to attend.

3 TUESDAY, JUNE 13 9:30 a.m.

Chemical Manufacturing

Chemical Milling—Now a Precision Science,[1] by *J. E. Trankla*, Anadite, Inc.

Closed Loop Control by Gas Chromatography,[1] by *E. E. Escher*, Consolidated Electrodynamics Corp.

Use of Perlite as a Filter Aid,[1] by *Paul Leppla*, Great Lakes Carbon Co.

PRODUCTION ENGINEERING SESSIONS

1 MONDAY, JUNE 12 9:30 a.m.

Jointly With Machine Design

Forming, Trimming, and Edge Finishing of Molybdenum-0.5 per cent Ti. Sheet Material, by *A. L. Pickrell*, Boeing Airplane Co. (Paper No. 61—SA-6)

Machinability of Nodular Cast Irons—Part 2. Effect of Cutting Conditions on Flank Adhesion, by *Katsundo Hitomi*, Kyoto Univ., Kyoto, Japan, and *G. L. Thuering*, Pennsylvania State Univ. (Paper No. 61—SA-7)

2 MONDAY, JUNE 12 2:30 p.m.

Jointly With Machine Design

Recent Developments in Explosive Metal-Fabrication Techniques,[1] by *L. Zernow* and *Irving Lieberman*, Aerojet-General Corp.

Residual Stresses in Explosively Formed Parts,[1] by *E. K. Henriksen*, Aerojet-General Corp.

SAFETY SESSIONS

1 MONDAY, JUNE 12 9:30 a.m.

Panel Discussion: Safety Practices in Petroleum Industry

Safety With E's,[2] by *W. J. Maynard*, Union Oil Co. of California

Manufacturing and Refining,[2] by *M. T. Hamilton*, Mobil Oil Refinery

Transportation and Pipelines,[2] by *J. G. Bridgeman*, Shell Oil Co.

Marketing,[2] by *A. R. Bowles*, Texaco Corp.

The Mechanical Engineer's Responsibilities to Safety in the Petroleum Industry,[2] by *J. U. Parker*, Humble Oil & Refining Co.

2 MONDAY, JUNE 12 2:30 p.m.

Jointly With Nuclear Engineering

Panel Discussion: Safety Considerations for the Applications of Radioisotopes in Industry

Industrial Radiography,[2] by *G. L. Locher*, Western Radiation Lab.

Testing and Quality Control,[2] by *Philip Ohmart*, Ohmart Corp.

Safety Aspects of the Use of Radioactive Materials in the Petroleum Industry,[2] by *V. P. Guinn*, Shell Dev. Co.

Weld Studies With Radioisotopes,[2] by *R. M. Brown*, Douglas Aircraft Co., Inc.

3 TUESDAY, JUNE 13 9:30 a.m.

Jointly With Management

Panel Discussion: Mechanical Engineer in Safety Management

Paper and Lumber Industry,[2] by *J. F. Robertson*, Crown Zellerbach Corp.

Objective—Frequency "O,"[2] by *R. W. Pett*, U. S. Steel Corp.

Aircraft Industry,[2] by *L. C. Pillsbury*, Douglas Aircraft Co., Inc.

Automotive Industry,[2] by *L. B. Wocholski*, Gen. Motors Inst.

SOLAR ENERGY SESSION

WEDNESDAY, JUNE 14 9:30 a.m.

Solar Distillation

Performance of a Solar Still, by *C. R. Garrett*,

[1] Paper not available—see box on page 126.

[2] Not to be printed.

Open Hearings for ASME National Nominations

THE 1961 Nominating Committee is to meet June 12–13, 1961, at the Statler Hilton Hotel in Los Angeles, Calif., during the Summer Annual Meeting. The Nominating Committee has scheduled open hearings so that members may speak in behalf of candidates for the office of President, Regional Vice-Presidents, and Directors. The schedule of these meetings is as follows:

Monday, June 12	9:00 a.m. to 12:00 noon
	1:30 p.m. to 4:45 p.m.
Tuesday, June 13	8:30 a.m. to 12:00 noon

The Organization Meeting for the 1962 Nominating Committee is scheduled for Wednesday, June 14, at 9:30 a.m.

Univ. of Puerto Rico, Mayaguez, Puerto Rico and *E. A. Farber*, Univ. of Florida. (Paper No 61—SA-38)

Solar Distillation Research at the University of California, by *E. D. Howe* and *L. H. Mac Leod*, Univ. of California. (Paper No. 61—SA-37)

New Applications of Thermodynamic Principles to Solar Distillation, by *W. N. Grune, T. L. Thompson,* and *R. A. Collins*, Georgia Inst. of Tech. (Paper No. 61—SA-45)

STUDENT MEMBER COMPETITION

1961 OLD GUARD PRIZE

1 TUESDAY, JUNE 13 9:30 a.m.

To help the young engineer bridge the gap between college and professional life is the aim of the Old Guard Committee—organized 24 years ago to administer the voluntary contributions of many Dues Exempt Members. These funds provide travel expense to selected Student Members and young Associate Members for attendance at national and regional meetings, and to assist the National Junior Committee in various activities. A high light of the Old Guard program is a national Papers Contest which is held each year at the Summer Annual Meeting of the Society. The first prize winners of the competitions in the 12 annual Regional Student Conferences are invited to participate in this event as guests of the Old Guard. The Student Member judged to have presented the best paper will be awarded $150. In addition, he will receive an expense paid trip to the Winter Annual Meeting, this year in New York City, where he will re-present his paper before the Society members and receive his award from the President of the ASME.

The names of six winners from Regional Student Conferences will appear in the final program after selection has been determined at conclusion of the last Student Conference on May 5–6, 1961.

2 TUESDAY, JUNE 13 2:30 p.m.

The names of six additional winners from Regional Student Conferences will appear in the final program after selection has been determined at conclusion of the last scheduled Student Conference, May 5–6, 1961.

WOMEN'S PROGRAM

SUNDAY, JUNE 11

3:00 p.m. Registration
4:00 p.m. "Early Bird" Reception

MONDAY, JUNE 12

San Fernando Mission Tour and Luncheon
12:15 p.m. President's Luncheon
6:30 p.m. Tour of Disneyland

TUESDAY, JUNE 13

Huntington Library Tour and Luncheon at Huntington Sheraton Hotel

WEDNESDAY, JUNE 14

Marineland and Palos Verdes Area Tour and Luncheon

INSPECTION TRIPS

Ford Motor Company

Ford Motor Company will host a tour at its Pico Rivera Facility on Monday, June 12. Built in 1956 on 200 acres of ground, the plant houses 29.7 acres under roof.

The plant is considered one of the most modern automobile assembly plants in the country and includes such things as more than 150 conveyers totaling more than 7 miles, facilities for 16 trucks and 36 railroad cars inside the building at one time, complete steam producing facility, and complete plant hospital.

Beckman Instruments, Incorporated

A tour of the Fullerton headquarters of Beckman Instruments, Inc., will be made from 2:30 to 4:30 p.m., Wednesday, June 14.

Beginning with an orientation period, the afternoon will include guided tours of the Company's research, engineering, and manufacturing facilities. Guides will be mechanical-engineering oriented. Tour groups will be limited to ten persons each to facilitate discussion.

Founded in 1935, with the introduction of the first commercially available meter for the measurement of acidity or alkalinity of solutions, the Company now markets more than 400 different products, with annual sales exceeding $60 million.

Situated on 67 acres with 450,000 sq ft under roof, the four divisions—Systems, Scientific and Process Instruments, Helipot, and Special Projects—will display many examples of the Company's product lines. In addition to pH meters, visitors will see spectrophotometers, which employ precision optical means for rapid chemical analysis, helical potentiometers, atmosphere monitoring and equipment, industrial process monitoring, and control equipment and data processing systems.

ASME Mexico Postsummer Annual Meeting Tour

Departing Los Angeles, June 15, 1961

THIS year, ASME is planning an exciting addition to the Summer Annual Meeting program. Why not take your vacation at Summer Annual Meeting time and join a wonderful trip to Mexico. We will leave Los Angeles, June 15, and be in Mexico City a few hours later. From there you may choose between a seven-day program in cosmopolitan Mexico and a ten-day program which adds four nights in Acapulco. On June 21, you may fly directly to your home city, or better, be in Acapulco. Depart on June 24, for the return flight to Mexico City to connect with your flight home.

Program I Includes

Transfer from hotel to airport in Los Angeles; Jet flight from Los Angeles to Mexico City; All transfers and baggage handling; Six nights at Hilton Continental Hotel, European Plan, including all gratuities; Sight-seeing tours of Mexico City, Xochimilco, bullfights, Guadalupe, and the Pyramids; and gala welcome cocktail reception at the hotel.

All-inclusive price: $195 per person, double occupancy

Program II Includes

Five nights at the Continental Hotel and all other features of Program I.

Limousine transfer from Mexico City to Acapulco, including lunch at the Vista Hermosa and an afternoon of shopping and sight-seeing at Taxco.

Four nights at the Las Brisas, including two daily meals, hotel tips, and gratuities; and Return air transportation from Acapulco to Mexico City.

All-inclusive price: $305 per person, double occupancy

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Heat-Transfer Engineers and Scientists to Meet at Boulder, Colo., for Second International Heat Transfer Conference

THE colorful campus of the University of Colorado at Boulder will be headquarters for United States and foreign engineers and scientists attending the Second International Heat Transfer Conference. The five-day conference, Aug. 28 to Sept. 1, 1961, will have approximately 125 papers available for discussion on the general theme "New Developments in Theory and Practice." Nine sessions are scheduled at which the papers will be summarized in topical groups by reporters, followed by written and oral discussions from the floor.

The sponsors and cohosts of the conference are The American Society of Mechanical Engineers and the American Institute of Chemical Engineers. The United Kingdom is represented by The Institution of Mechanical Engineers and The Institution of Chemical Engineers. Participating societies are the American Chemical Society; The American Nuclear Society; the American Rocket Society; the American Society of Heating, Refrigerating and Air-Conditioning Engineers; The Chemical Institute of Canada; The Engineering Institute of Canada; the Institute of the Aerospace Sciences; and the Society of Automotive Engineers. Through the combined efforts of all these societies papers will be available for discussion from the U. S. A., U. K., Canada, Japan, USSR, France, Switzerland, Australia, Italy, Germany, Sweden, and other countries.

Special Lectures. Four special lectures will be given during the conference. Owen A. Saunders, President of The Institution of Mechanical Engineers, will deliver the ASME Calvin Rice Lecture, "Some Reflection on Progress in Engineering Heat-Transfer Science." E. R. G. Eckert, University of Minnesota, will lecture on "Research During the Last Decade on Forced Convection Heat Transfer." E. A. Schmidt, Munich, West Germany, will lecture on "Heat Transfer by Natural Convection," while H. C. Hottel, Mem. ASME, Massachusetts Institute of Technology, will lecture on "Problems in Radiative Transport."

A series of special events and activities have been planned by the local committee starting with the Early Bird Party on Sunday. A Smorgasbord Dinner, trip to Estes Park, and banquet are planned for later in the week. The Awards Luncheon on Wednesday will be the occasion for presenting the National Heat Transfer Conference Award to E. R. Quandt for his paper, "Analysis and Measurement of Flow Oscillations," presented at the Buffalo Conference, August, 1960.

For the women the committee has arranged for a Fashion Show at Monday's luncheon. This will be followed on succeeding days by a trip to the Air Force Academy at Colorado Springs and historic Central City. Visitors attending the conference who may wish to make other sight-seeing trips on their own will find numerous places of interest within easy driving distance.

All who plan to attend the conference are urged to register in advance. Advance registrants will receive, approximately 30 days before the opening date, bound copies of all papers to be discussed. These will be bound in five books, one for each day's sessions. Full information on registration and advance program may be obtained by writing to ASME, Meetings and Divisions, 29 West 39th Street, New York 18, N. Y.

The annual national ASME Heat Transfer Conference has been combined with this international conference.

▶MONDAY, AUGUST 28

Heat Conduction and Thermoelectric Effects — 9:00 a.m.

The Method of Finite Integral Transforms in Heat-Transfer Problems, *S. Kaplan* and *G. Sonnemann*, U. S. A.

The Effect of Discontinuous Biot Number on the Temperature Distribution in Moving Slabs, *G. Horvay*, U. S. A.

Calculation of Unsteady Heat Conduction in Single-Layer and Composite Finite Slabs With and Without Property Variations by an Improved Integral Procedure, *Kwang-Tzu Yang*, U. S. A.

Lumping Errors of Analog Circuits for Heat Flow Through a Homogeneous Slab, *D. G. Stephenson* and *G. P. Mitalas*, Canada

An Hydraulic Analogy to Transient Conduction in Two-Dimensional Fields, *F. C. Hooper, C. H. Miller*, and *J. F. Keffer*, Canada

Temperature Distribution in Ring and Plug Shrink Fit Assemblies, *R. Hendry*, U. K.

Heat Transfer From the Uranium Fuel to the Magnox Can in a Gas-Cooled Reactor, *P. D. Sanderson*, U. K.

The Thermal Conductance of Machined Metal Contacts, *L. C. Laming*, U. K.

Interfacial Temperatures and the Distribution of Heat Between Bodies in Sliding Contact, *T. P. Newcomb*, U. K.

Thermoelectric Generator Efficiency, *R. L. Sampson*, U. S. A.

An Exact Method for Determining the Theoretical Performance of a Thermoelectric Generator When Material Properties Are Arbitrary Functions of Temperature, *D. L. Kerr*, U. S. A.

Heat Transfer in Equipment—I — 2:30 p.m.

Laboratory Test Results With a Family of Heating Elements for Ljungstrom Air Preheaters, *A. Lysholm, T. J. McVeigh*, and *R. Gustafsson*, Sweden

The Solution to the Dimensions of Corrugation-Type Heat Exchangers, *R. J. V. Snell*, U. K.

Heat-Transfer and Flow-Friction Characteristics of Five Offset Rectangular and Six Plain Triangular Plate-Fin Heat-Transfer Surfaces, *D. C. Briggs* and *A. L. London*, U. S. A.

Heat-Transfer Coefficients in Town-Gas Heated Equipment, *E. A. K. Patrick* and *N. G. Patel*, U. K.

Experiments on Flame Radiation in an Air-Cooled Steel Muffle Combustor and a Complementary Water-Cooled Furnace, *A. Lysholm* and *N. Gunners*, Sweden

Calculation of a Flue-Gas Recirculation and Heat Transfer in Heaters Using High-Velocity Gas Burners, *W. E. Francis* and *(Miss) H. E. Roughton*, U. K.

Heat Transfer to Rocket-Engine Injectors, *S. L. Bragg* and *I. E. Smith*, U. K.

Radiation and Convection in High-Energy Liquid-Propellant Rocket Engines, *H. Ziebland*, U. K.

Heat Transfer in Diesel Engines, *J. F. Alcock*, U. K.

Air Cooling of Small Gas-Turbine Disks, *U. Oprecht*, Switzerland

The Development of Small Gas Turbines of Low Weight and High-Part Load Efficiency, *A. T. Bowden* and *W. Hryniszak*, U. K.

Heat Transfer During Evaporation of High Quality Water-Steam Mixtures Flowing in Horizontal Tubes, *C. Rounthwaite* and *M. Clouston*, U. K.

▶TUESDAY, AUGUST 29

Boiling and Burnout, Condensation, and Two-Phase Flow — 9:00 a.m.

Bubble Growth in Nucleate Boiling of a Binary Mixture, *J. E. Benjamin* and *J. W. Westwater*, U. S. A.

Heat Transfer in Film Boiling to Subcooled Liquids, *F. Tachibana* and *S. Fukui*, Japan

Boiling Heat Transfer From a Flat Surface Facing Downward, *S. Ishigai, K. Inoue, S. Kiwaki*, and *T. Inai*, Japan

The Hydrodynamic Crisis in Pool Boiling of Saturated and Subcooled Liquids, *N. Zuber, M. Tribus*, and *J. W. Westwater*, U. S. A.

Critical Boiling in Tubes. *V. E. Doroshchuk* USSR

Availability of Papers

THE individual papers which will be reported and discussed at Boulder will be ready for distribution July 3, 1961. The registration fee includes one (1) bound copy of all papers, mailed to you before the Conference, if the Advance Registration form, with remittance, is received by July 3, 1961; otherwise the volume of papers may be obtained at the Conference when you register. Additional copies will be available at the Conference.

The papers in this program will *not be available in separate copy form.* The book of papers will be available to nonregistrants on Aug. 28, 1961, for $22 a copy. **You can save postage and handling charges by including your check or money order made payable to ASME with your order and sending both to: ASME Order Department, 29 West 39th Street, New York 18, New York. After Sept. 1, 1961, address will be: United Nations Plaza at 47th Street, New York 17, N. Y.**

For a copy of the Program, which includes the Advance Registration form, write to: ASME, Meetings and Divisions, 29 West 39th Street, New York 18, N. Y.

Transient Pool Boiling of Water at Atmospheric Pressure, *H. A. Johnson, V. E. Schrock, F. B. Selph, J. H. Lienhard,* and *Z. Rosztoczy,* U. S. A.

Burnout Heat Fluxes in Pool Boiling at High Accelerations, *C. P. Costello* and *J. M. Adams,* U. S. A.

Burnout in Crossed-Rod Matrices Under Forced Convection Water Flow, *S. P. Kezios, Tong-Soq Kim,* and *F. M. Rafchiek,* U. S. A.

An Experimental Investigation of Over-All Heat-Transfer Coefficients for Condensing and Boiling Hydrogen Films, *K. D. Timmerhaus, J. W. Dean,* and *D. E. Drayer,* U. S. A.

Heat Transfer by Condensing Pure Vapors Outside Inclined Tubes, *G. Selin,* Sweden

Dropwise Condensation of Steam, *R. G. H. Watson, J. J. Brunt,* and *D. C. P. Birt,* U. K.

Microscopic Study of Dropwise Condensation, *J. W. Westwater* and *J. F. Welch,* U. S. A.

The Condensation of Steam on a Tube With Filmwise Condensation and in the Presence of a Noncondensable Gas, *H. Hampson,* U. K.

Some Hydrodynamic Aspects of Two-Phase Flow and Boiling, *G. B. Wallis,* U. K.

Two-Phase (Steam and Water) Flow and Heat Transfer, *M. Silvestri,* Italy

High-Pressure Superheater Steam in an Annulus, *J. G. Collier* and *P. M. Lacey,* U. K.

Two-Phase Pressure Gradient, *W. L. Owens,* U. K.

High-Speed Flows, Aspects of External Convection, Vibrations, and Pulsating Flows 2:30 p.m.

Heat-Transfer Investigations for the Flow of Steam Ranging Up to Sonic Velocity, *A. W. Scott* and *R. M. G. Meek,* U. K.

Measurements of Heat Transfer in Bubbles of Separated Flow in Supersonic Air Streams, *A. Naysmith,* U. K.

A Technique for Solving the Laminar-Boundary Layer Equations Applicable to Three-Dimensional Compressible Flows, *M. Epstein,* U. S. A.

Pressure and Laminar Heat-Transfer Distribution at the Nose Region of a Three-Dimensional Body, *V. Zakkay* and *M. Visich, Jr.,* U. S. A.

The Aerodynamic Heating of Blunt, Axisymmetric, Re-Entry Type Bodies With Laminar-Boundary Layer at Zero and at Large Angles of Yaw in Supersonic and Hypersonic Air Streams, *S. M. Hastings, L. Pasiuk,* and *A. J. Chones,* U. S. A.

Boundary-Layer Similar Solutions for Equilibrium Dissociated Air and Application to the Calculation of Laminar Heat-Transfer Distribution on Blunt Bodies in High-Speed Flow, *N. B. Cohen* and *I. E. Beckwith,* U. S. A.

The Heat Transfer and Friction Characteristics for Forced Convection Air Flow Over a Particular Type of Rough Surface, *F. J. Edwards* and *N. Sheriff,* U. K.

Heat Transfer to the Air Flow in a Surface Cavity, *R. A. Seban* and *J. Fox,* U. S. A.

Influence of Turbulence on the Transfer of Heat From Plates With and Without a Pressure Gradient, *J. Kestin, P. F. Maeder,* and *H. E. Wang,* U. S. A.

Heat Transfer to a Turbulent Steam From a Surface With a Step Wise Discontinuity in Wall Temperatures, *D. B. Spalding,* U. K.

Turbulent Transfer From Isothermal Spanwise Strips on a Flat Plate, *H. H. Sogin* and *R. J. Goldstein,* U. S. A.

Heat-Transfer Between a Flat Plate and Jets of Air Impinging on It, *R. Gardon* and *J. Cobonpue,* U. S. A.

Convection Heat Transfer From a Rotating Sphere, *R. L. Nordlie* and *F. Kreith,* U. S. A.

Unsteady Heat Transfer From a Rotating Disk and at a Stagnation Point, *E. M. Sparrow* and *R. D. Cess,* U. S. A.

Use of Thermodynamic Similarity in Generalizing Experimental Data of Heat Transfer, *V. M. Borishansky, I. I. Novikov,* and *S. S. Kutateladze,* USSR

The Effects of Resonant Acoustic Vibrations on the Nusselt Numbers For a Constant Temperature Horizontal Tube, *T. W. Jackson, K. R. Purdy,* and *C. C. Oliver,* U. S. A.

The Influence of Vertical Vibrations on Heat Transfer by Free Convection From a Horizontal Cylinder, *R. M. Fand* and *J. Kaye,* U. S. A.

The Effect of Flow Pulsations on Heat Transfer by Forced Convection From a Flat Plate, *F. J. Bayley, P. A. Edwards,* and *P. P. Singh,* U. K.

Heat Transfer Between a Flat Plate and a Pulsating, Impinging Jet, *R. G. Nevins* and *H. D. Ball,* U. S. A.

Two-Dimensional Pulsating Laminar Flow in a Duct With a Constant Wall Temperature, *R. Siegel* and *M. Perlmutter,* U. S. A.

▶WEDNESDAY, AUGUST 30

Internal and Duct Flow 9:00 a.m.

Heat Transfer to Mercury in Parallel Flow Through Bundles of Circular Rods, *A. J. Friedland, M. W. Maresca, C. F. Bonilla,* and *O. E. Dwyer,* U. S. A.

Measurements of Heat-Transfer Coefficients, Friction Factors, and Velocity Profiles for Air Flowing Parallel to Closely Spaced Rods, *L. D. Palmer* and *L. L. Swanson,* U. S. A.

Improvement of Fuel Element Heat Transfer by Use of Roughened Surfaces and the Application to a 7-Rod Cluster, *A. Draycott* and *K. R. Lawther,* Australia

Heat Transfer With Axial Flow in Rod Clusters, *H. W. Hoffman, J. L. Wantland,* and *W. J. Steizman,* U. S. A.

Heat Transfer to Supercritical Water at 5000 Psi Flowing at High-Mass-Flow Rates Through Round Tubes, *K. Goldmann,* U. S. A.

An Investigation of Heat Transfer to Fluids Flowing in Pipes Under Supercritical Conditions, *B. S. Petukhov, E. A. Krasnoschekov,* and *B. S. Protopopov,* USSR

Computer Reference Temperatures for Turbulent Variable-Property Heat Transfer in a Tube for Several Common Gases, *R. G. Deissler* and *A. F. Presler,* U. S. A.

Turbulent Heat Transfer in the Critical Region, *J. M. Smith* and *L. Koppel,* U. S. A.

Simultaneous Developments of Temperature and Velocity Profiles in Flat Ducts, *L. S. Han,* U. S. A.

Method of Conformal Mapping in Forced Convection Problems, *L. N. Tao,* U. S. A.

The Effect of a Longitudinally Varying Wall-Heat Flux on the Heat-Transfer Coefficient for Turbulent Flow in a Pipe, *W. B. Hall* and *P. H. Price,* U. K.

Effects of Longitudinal Thermal Conduction in the Solid on Apparent Convection Behavior With Data for Plate-Fin Surfaces, *J. R. Mondt,* U. S. A.

Transient Heat Transfer in a Convection-Cooled Heterogeneous Nuclear Reactor With Axial Power Density, *W. O. Doggett* and *R. H. Shultz, Jr.,* U. S. A.

The Effect of a Right-Angled Bend on Heat Transfer in a Pipe, *A. J. Ede,* U. K.

The Effects of Onset of Taylor Vortices on Heat Transfer, *F. C. Haas* and *A. H. Nissan,* U. S. A.

Turbulent Heat Transfer in Pseudoplastic Non-Newtonian Fluids, *R. M. Clapp,* U. K.

The Ratio of the Eddy Diffusivities for Heat and Momentum and Its Effect on Liquid Metal Heat-Transfer Coefficients, *T. Mizushina* and *T. Sasano,* Japan

▶THURSDAY, AUGUST 31

Mass Transfer, Packed, and Fluidized Beds 9:00 a.m.

An Investigation Into Film Cooling by Slots, *C. M. Milford* and *D. M. Spiers,* U. K.

Heat Transfer on a Surface Covered by Cold Air Film, *A. Tsuchida, N. Nishiwaki* and *M. Hirata,* Japan

Velocity Distributions, Temperature Distributions, Effectiveness, and Heat Transfer in Film Cooling of a Surface With a Pressure Gradient, *J. P. Hartnett, R. C. Birkebak,* and *E. R. G. Eckert,* U. S. A.

Heat and Mass Transfer of Air Cooling Coils With Fins, *H. Uchida,* Japan

Mass Addition Effects on Hypersonic Heat Transfer to a Two-Dimensional Body, *S. M. Scala* and *W. F. Ashley,* U. S. A.

The Sublimation of Granular Solids, *T. K. Ross* and *A. Rushton,* U. K.

Cooling and Dehumidification of Gases—Inside and Outside of Tubes, *B. L. Baker* and *K. O. Beatty, Jr.,* U. S. A.

Laminar Nonisothermal Pipe Flow With Coolant Injection at Wall, *S. W. Yuan* and *Y. Peng,* U. S. A.

Calculation of Transient Ablation, *M. Zlotnick* and *B. Nordquist,* U. S. A.

Transient Heating at an Axisymmetric Stagnation Point With Mass Addition, *W. P. Manos* and *D. E. Taylor,* U. S. A.

Heat Transfer by a Fluidized Bed, *S. S. Zabrodsky,* USSR

Radially Effective Thermal Conductivities in Packed Beds, *S. Yagi, D. Kunii,* and *N. Wakao,* Japan

Studies on Heat Transfer in Packed Beds, *S. Yagi* and *D. Knuii,* Japan

An Experimental Investigation of the Local Packing and Heat-Transfer Processes in Packed Beds of Homogeneous Spheres, *J. Wadsworth,* U. S. A.

The Measurement of Heat-Transfer Coefficients in Packed Beds by the Cyclic Method, *R. M. G. Meek,* U. K.

Performance of Thermal Regenerators Under Sinusoidal Flow Conditions—Part I, *J. A. Murray* and *B. W. Martin,* U. K.

Performance of Thermal Regenerators Under Sinusoidal Flow Conditions—Part II, *F. J. Bayley* and *C. W. Rapley,* U. K.

Radiation, Thermal Properties, and Instrumentation 2:30 p.m.

Prediction of the Emissivity of Hydrocarbon Flames, *M. W. Thring, J. S. Ashton, P. J. Foster,* and *I. A. McGrath,* U. K.

Radiant Heat Transfer From Luminous Flame, *T. Sato* and *R. Matsumoto,* Japan

Equilibrium Emissivity Calculations for CO_2, *M. Lapp, L. D. Gray,* and *S. S. Penner,* U. S. A.

Heat Transfer in a Thermal Radiation Absorbing and Scattering Medium, *R. Viskanta* and *R. J. Grosh,* U. S. A.

An Examination of Two-Dimensional Heat-Transfer Configuration Factors With Absorbing Medium, *M. S. Rhodes,* U. K.

Study on the Emissivity of a Gas Which Contains Particles, *S. Yokobori,* Japan

The Thermal and Electrical Conductivity of Liquid Mercury, *R. W. Powell,* U. K.

An Optical Method for Measuring the Thermal Diffusivity of Solids, *A. Hirschman, J. Dennis, W. Derksen,* and *T. Monahan,* U. S. A.

Helium Prandtl Number Measurements and Calculated Viscosity and Thermal Conductivity, *P. D. Stroom, W. E. Ibele,* and *T. F. Irvine, Jr.,* U. S. A.

Characteristics of Heat-Flux Probe for Use in High-Temperature Atmospheres, *L. M. Fingerson* and *P. L. Blackshear,* U. S. A.

▶FRIDAY, SEPTEMBER 1

Heat Transfer in Equipment—II 9:00 a.m.

An Analysis of Heat Transfer in the Hickman Rotary Evaporator, *A. A. Putnam, J. A. Eibling,* and *W. L. Buckel,* U. S. A.

Solar Water Distillation, the Roof-Type Still, and a Multiple Effect Diffusion Still, *R. V. Dunkle,* U. S. A.

Tests on a Rotating Tube Heat Exchanger Having Controlled Fluid Flow, *R. F. Pettenden* and *A. D. Richards,* U. K.

Performance Coefficients for Cooler-Condensers in the Gas Industry, *G. S. Cribb,* U. K.

The Fusion of Granular Solids, *T. K. Ross,* U. K.

Heat and Mass Transfer in Sublimation Drying of Foods, *J. C. Forrest, J. M. Dalgeish,* and *H. P. Thompson,* U. K.

Heat-Transfer and Pressure-Drop Data on Cooling-Tower Packings, and Model Studies of the Resistance of Natural Draught Towers to Airflow, *H. J. Lowe* and *D. G. Christie,* U. K.

The Design of a Natural Draught Cooling Tower, *R. F. Rish,* U. K.

Local Shell-Side Heat-Transfer Coefficients in a Leak-Proof Heat Exchanger, *B. Short* and *J. W. Stachiewicz,* Canada

Metallic Screen Thermoinsulators, *D. V. Velickovic,* Yugoslavia

Free Convection 2:30 p.m.

Natural Convection Heat Transfer in Long Horizontal Cylindrical Annuli, *Chen-Ya Liu, W. K. Mueller,* and *F. Landis,* U. S. A.

Computation of Natural Convection by Finite Difference Methods, *J. D. Hellums* and *S. W. Churchill,* U. S. A.

Natural Convection in a Liquid Containing a Distributed Heat Source, *D. Wilkie* and *S. A. Fisher,* U. K.

Natural Convection in Viscous Oil, *J. Holt, R. G. S. Skipper,* and *O. A. Saunders,* U. K.

Free Convective Heat Transfer to a Supercritical Fluid, *C. A. Fritsch* and *R. J. Grosh,* U. S. A.

Stability of Laminar Viscous Flows With a Body Force, *S. Ostrach* and *S. H. Maslen,* U. S. A.

Heat Transfer of Particles in the Domain Where Natural and Forced Convections Coexist, *T. Tsubouchi* and *S. Sato,* Japan

On Combined Free and Forced Convective Laminar Magnetohydrodynamic Flow and Heat Transfer in Channels With Transverse Magnetic Field, *Y. Mori,* U. S. A.

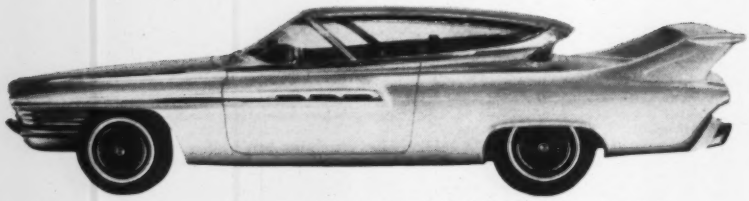
Rising Costs Affect Defense Department Research, Says J. R. Rubel at ASME Gas Turbine Power Conference

Military and industrial leaders join in Washington to discuss status of Gas Turbine Power developments

J. R. Rubel says, "Growing costs are having a profound effect on the type of research being done by the Department of Defense"

Curt Keller, Mem. ASME, discusses the coal-burning closed-cycle gas turbine

Rear Admiral R. K. James, chief, Bureau of Ships, presents paper on Sea Power: Gas Turbines Add More Fighting Punch



Chrysler's "dream boat," the "Turboflite," on exhibit at Gas Turbine Power show at Washington's Shoreham Hotel

At the banquet, **left to right:** J. W. Sawyer, GTP Division chairman; D. E. Marlow, Vice-President, ASME Region III; J. H. Rubel, speaker; Navy Chaplain N. D. Lindner; G. J. Huebner, Jr., executive engineer in charge of research, Chrysler Corporation; R. T. Sawyer, GTP Division treasurer; J. W. Abouchar, chairman of the General Arrangements Committee

"Growing costs are having a profound effect on the type of research that is being done by the Department of Defense," said John R. Rubel, deputy director of defense, research, and engineering, Office of the Secretary of Defense. In his banquet address at the Gas Turbine Power Conference on the "Rising Costs of Research and Development," Mr. Rubel pointed out that much of the work that should be done will have to be deferred unless cost can be controlled. Ninety per cent of the $6-billion research and development budget now goes to 250 projects, and more than one third of it is represented by only five projects.

More than 700 attended the Gas Turbine Power Conference at the Hotel Shoreham, Washington, D. C., March 5–9, which was jointly sponsored by the ASME Gas Turbine Power Division and the Department of Defense.

"The Nike-Zeus development alone," said Mr. Rubel, "will cost about $2 billion, and the B-70 is currently estimated to cost over $2½ billion for the research, development, and testing phase."

For every dollar spent on supplying actual weapons, 50 cents is spent on developing a new one. Fighters cost 60 times as much as in World War II, and some other replacement costs are 100 times as much. The cost per pound is rising so rapidly that by 1975 airplanes will actually equal the cost of gold per pound—some electronic apparatus already costs more!

Mr. Rubel concluded that "only a team effort of the highest order, involving industry on the one hand and government management on the other, can hope to reverse this trend which promises nothing but steadily diminishing rewards for industry and—ultimately—some measure of disaster for our nation. The bright side of the coin is that this same team has often accomplished the seemingly impossible."

John W. Sawyer of the Applied Research Division, Bureau of Ships, chairman of the ASME Gas Turbine Power Division, was banquet toastmaster. This event also was the occasion when the Division made a contribution to the Member Gifts Campaign for the United Engineering Center. The check was accepted on behalf of the Society by ASME President W. H. Byrne.

Conference Program. The program had some of the earmarks of an annual meeting in miniature. Not only did it cross divisional lines in discussing the nuclear maritime gas-cooled reactor, but there were several sessions each on design problems and power generation, and one

on metallurgy. An operational-experience report on Union Pacific's 8500-hp gas-turbine-locomotive fleet and on the adaptation of aircraft gas-turbine engines to industrial power requirements rounded out the program.

Military Reports. In the military reports, the U. S. Navy ignored the gas turbine's part in supplying prime power and concentrated on such auxiliary uses as hydrofoil and amphibious craft, flight-deck tractors, and small craft. A report from Associated Electrical Industries (Manchester), Ltd., filled in on a boost-propulsion use with a 7500-shp gas turbine developed for the Admiralty.

The Army's report was primarily on development, except for aircraft, where "Army aircraft are already powered by gas turbines." The Corps of Engineers, the Ordnance Corps, and the Transportation Corps all have developmental responsibility.

The Air Force took a historical approach to jets, which is a *fait accompli* as far as they are concerned. The pioneering role the Air Force has played was stressed, along with the way in which it has affected commercial aviation.

Industry Reports. Two versions of the closed-cycle gas turbine were presented. Curt Keller described a large coal-burning one that has been widely applied in Europe for industrial power requirements combined with hot-water central heating. Dr. Keller's paper will be published in MECHANICAL ENGINEERING. The nuclear application is still theoretical—for a maritime gas-cooled plant—and awaits feasibility confirmation (about 1963) with some component tests.

In the electric-power field a small standby plant used by Hydro-Quebec and large off-peak units for Orlando, Fla., (the latter paper is to be published in MECHANICAL ENGINEERING) were described.

Although aircraft gas turbines have been adapted to ground use before, the report on the joint Cooper-Bessemer Pratt-Whitney effort offered a new twist. Approached from the marketing end it tended to treat some difficult engineering problems rather casually.

Exhibits. The military aspect of the conference carried through to the exhibits. The Army provided hourly bus service to the Pentagon where a number of vehicular gas-turbine applications were in operation. The Navy had a special one-trip showing of a 5000-kw mobile power plant.

Vehicles were in the forefront of the exhibits at the Shoreham. Chrysler's "dream boat" of a car, the "Turboflite," had been converted into actuality, complete with luminous-panel lighting (on the backs of the front seats), an elevating solid top (to admit the passengers), and a "wing" between the largest tail fins yet. Gas-turbinewise, the Turboflite offers a variable-nozzle system with good part-load fuel consumption and quick response. It is a 45,000-rpm unit with a 1700-F inlet temperature.

The General Motors Whirlfire GMT-305 engine (MECHANICAL ENGINEERING, November, 1958, p. 111; September, 1959, pp. 53–56) and the Ford 704 gas-turbine engine (MECHANICAL ENGINEERING, June, 1959, pp. 79–80) were also on display. The Harrison Radiator Division of GM included in its display the simple padded-type heat-exchange structure of alternating corrugated and flat shims used in Whirlfire regenerator.

An unusually complete and instructive booth by the Department of Defense explained the operation and development of the gas-lubricated bearing.

There were 60 booths on components, metals, drives, and gas-turbine auxiliaries as well as the engines themselves.

Education, Registration, and Unity. Donald E. Marlowe, Vice-President, ASME Region III, in a talk on "Education, Registration, and Unity," in reality defined the place and significance of voluntary associations for the furtherance of professional interests. Dr. Marlowe, who is Dean of the School of Engineering and Architecture, Catholic University, stated that he could not but marvel at "the slender reed" on which we ultimately depend for the development of our technology. This extremely important functional unit in our way of doing things is actually at the "organized whim" of the many technical people who belong to our professional organizations.

Depending upon the gift of so much time and effort voluntarily contributed, and beyond the regular occupation of its members, it is part of a long tradition that is unique to Western civilization. Dedicated to the open exchange of information, it is in marked contrast to the guild system with its guarded secrets.

Although English-speaking countries customarily consider the learned or professional society to date from the founding of the Royal Society, the origins are considerably more ancient. Galileo belonged to a Society of the Lynx, whose object was "to seek out scientific truth with the eyes of the lynx."

It should be remembered, Dr. Marlowe stated, that the Royal Society was founded by amateurs, whereas today the scientific and technical organizations are composed almost wholly of professionals.

Dr. Marlowe stated that there are three hallmarks of a profession, each of which carries an obligation: (*a*) Creating and updating the body of knowledge that is the particular profession's special care; (*b*) partial dedication of service to the public good (this is easiest to see in the ministry, he noted, but exists in other professions); and (*c*) obligation to assure the continuity of the profession. Part of the national welfare and even survival, he pointed out, depend upon the extent to which these obligations are fulfilled.

Dudley D. Taylor of High Pressure Engineers, Inc., chairman of the ASME Washington Section, was toastmaster.

A dinner in honor of overseas guests was held by the technical committee at which each person told briefly of his interest in gas turbines and his reason for being at the conference.

Availability List—Gas Turbine Power Conference and Exhibit

THE papers in this list are available in separate copy form until Jan. 1, 1962. Please order only by paper number; otherwise the order will be returned. You can save the postage and handling charges by including your check or money order made payable to ASME with your order and sending both to the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Papers are priced at 50 cents each to members; $1 nonmembers. Payment also may be made by free coupons distributed annually to members, or coupons which may be purchased from the Society. Coupons, in lots of ten, are $4 to members; $8 to nonmembers.

61—GTP-1 A Gas Turbine "CO" Boiler Installation; Economic and Thermodynamic Analysis, by Charles Bultzo

61—GTP-2 The Coal-Burning Closed-Cycle Gas Turbine, by C. Keller and W. Gaehler

61—GTP-3 Use of Experimental Interstage Performance Data to Obtain Optimum Performance of Multistage Axial Compressors, by L. E. Brown and F. G. Groh

61—GTP-4 Standby Power for Hydro-Quebec Uses Gas Turbines, by H. W. Haberl and D. F. Abel

61—GTP-5 A 7500-Shp Gas Turbine for Naval Boost Propulsion, by F. R. Harris

61—GTP-6 The Orlando Gas Turbines, by C. H. Stanton and H. C. Luff

61—GTP-7 Design and Development Review of the T64 Turboprop/Turboshaft Engine, by F. F. Ehrich

61—GTP-8 Operation of 8500-Hp Gas Turbines in Locomotive Service, by H. Rees

61—GTP-9 Segregated Structures in Highly Alloyed Ferritic Gas-Turbine Wheel Forgings, by G. R. Heckman and A. W. Herbenar

61—GTP-10 Seapower: Gas Turbines Add Fighting Punch, by R. K. James

61—GTP-11 Practical Realizations of Gas Turbines Combined With Steam and Industrial Heat Cycles, by W. P. Auer

61—GTP-12 Design Considerations and Operating Experience of Regenerators for Industrial Gas Turbines, by R. F. Caughill

61—GTP-13 Transient Temperatures and Thermal Stress Problems in Small Gas Turbines, by R. R. Van Nimwegen

61—GTP-14 Technical Considerations in the Development of a Maritime Gas-Cooled Reactor System, by B. T. Resnick

61—GTP-15 Materials Keep Pace With Industrial Gas-Turbine Needs, by H. B. Gayley

Military Interest. Some of the military men attending Flight Simulator Panel during ASME Aviation Conference, March 14, 1961, at Statler Hilton Hotel, Los Angeles, Calif. **Left to right:** Wing Cmdr. J. R. Clayton; Col. D. H. Frank, USAF; Wing Cmdr. G. H. Shields, Australia; Col. Verne Bivin, USAF; Hurshel Martin, WADD; Col. Lingamfelter, USAF; Wing Cmdr. W. J. P. Straker; Maj. J. R. Noble, USAF; and Maj. J. L. Hughes, USAF.

Conference Marks

Flight Simulator Panel. Left to right: J. W. Hudson, FAA, Washington, D. C.; J. R. Gannett, Boeing Airplane Company, Renton, Wash.; Capt. R. F. Rowe, TWA, Kansas City, Mo.; H. B. Crockett, Lockheed Aircraft Corp., Burbank, Calif.; R. J. Yates, Qantas Empire Airways Ltd., Burbank, Calif.; L. L. Kelly, General Precision-Link Div., Binghamton, N. Y.; J. E. Ekstromer, Douglas Aircraft Company, Santa Monica, Calif. **Standing:** Herman Olson, acting Session Vice-Chairman, and W. B. Klemperer, both of Douglas Aircraft at Santa Monica.

International Flavor. Some of the foreign engineers attending ASME Aviation Conference. **First row, left to right:** Roberto Pini P., Cia Mexicana de Aviacion S.A., Mexico City; Hon. W. B. Griffiths, O.B.E., Ministry of Aviation, London, England; W. B. Houston, B.O.A.C., London; A. C. G. Martin, B.O.A.C. London; B. A. Heyman, K.L.M. Shiphol, Holland; and R. W. Davies, Department of Civil Aviation, Melbourne, Australia **Second row, left to right:** First man unidentified; I. D. Ralfe, Qantas Airways Ltd., Sydney, Australia; Capt. W. J. Johnson, B.E.A., London, England; A. H. Stewart, B.O.A.C., London; S. M. Poole, Le Materiel Telephonique, Paris, France; and Ron Cuming, Aero Research Labs., Melbourne, Australia.

At the Aviation Luncheon. A. E. Raymond, **left,** of Rand Corporation, Santa Monica, Calif., and toastmaster, greets The Hon. W. B. Griffiths, O.B.S., F.I.N. British Ministry of Aviation, London, England

Excitement Prevails Over Coming Advances

ASME Aviation Division Goes Into High Gear

The 1961 ASME Aviation Conference was held March 13-15 in the heart of one of the most dynamic centers of the aerospace industry: Los Angeles, Calif. With the Statler Hilton Hotel as headquarters, some 90 technical papers and talks were presented in 24 sessions, covering most of the current significant problem areas or advances in the field of aviation including guidance and instrumentation, structural design, production techniques, space transport, propulsion, and accessory equipment. For example, two panel discussions on flight simulators attracted some of the foremost authorities from three continents and resulted in a comprehensive and expert treatise of the subject.

Four Decades. At the 1960 ASME Winter Annual Meeting in New York, Past-President W. L. Cisler complimented the Aviation Division on its 40 years of service to ASME and to the profession. During these four decades, the technical advances in aviation have changed the face of the earth. Political conditions permitting, distances between the world's great metropolitan centers are no longer measured in miles or in time, but by the price of an airline ticket. A typical

example of this condition was provided by the many conference participants who converged from all corners of the world on southern California, without appreciable loss of time for travel. The luncheon speaker, the Honorable W. B. Griffiths, O.B.E., of the British Ministry of Aviation, flew overnight from London.

Those who made their way from New York to Los Angeles by nonstop jet, did so in a little over five hours.

The selection of the site and time for the Conference was most auspicious. Those who arrived at the Los Angeles Airport after dusk were greeted by a giant electric sign proclaiming the airport as the "HOME OF THE X-15." Throughout the Conference, contact with local engineers gave one the feeling that Los Angeles was well aware of its status as a great center of aviation, that it was carrying the ball and doing it well. Naturally a great deal of interest at the Conference centered on discussions involving the X-15, the vehicle which is carrying man to the threshold of space.

The ease with which the Conference participants gathered in Los Angeles represents an extraordinary engineering achievement; but the manner in which such accomplishments are taken for granted today is even more significant.

At the Conference. The 1961 ASME Aviation Conference papers constitute a comprehensive status report of the activities of the mechanical engineer in the aircraft and aerospace industry. One gets the feeling that we cannot visualize a limit to what can be accomplished from a technical standpoint. We are approaching the unique situation where there are no technical problems for which feasible technical solutions do not seem to exist. There was a spirit of excitement at this Conference, in looking forward, in anticipating the things to come. In all areas, engineers stand on the threshold of major technical breakthroughs.

at Los Angeles

What Lies Ahead. In practically all problem areas, the basic theories have been worked out and feasibility studies point the way to the next steps. The big task now is to follow through with the hardware. However, this involves more than just engineering. There must be a customer; a customer with a specification. Before a specification can be created, on the other hand, the customer must be educated with respect to his needs and to the possible technical solutions. These matters go far beyond the capabilities and responsibilities of the engineer. For example, the panel discussions on flight simulators pointed out the necessity for co-ordinating, in important matters affecting the public safety, some of the basic major programs and procurement schedules of the airlines, the Air Force, the Navy, the FAA, the aircraft and equipment manufacturers, and the flight-simulator manufacturers. Certain aspects of national policy are involved. Until such monumental problems are solved on their proper level, the nation cannot fully benefit from the contribution of the engineer.

The development of workable, complex air and space hardware also presents other difficulties not normally understood by those outside the designer's immediate fraternity. Design of complex hardware is not a straightforward analytical task. There are many parameters involved, and many technical factors to consider. Many of these factors cannot be analytically treated, and it becomes something of an art to balance them all out to achieve the optimum trade-offs which result in a workable piece of hardware. It takes not only formulas and a slide rule, but also know-how, experience, and a feeling for the work. Cut-and-try methods are involved. Unfortunately, this aspect of mechanical engineering is not always recognized by all of those who direct the activities of the engineer and the specification writer. Inadequate attention is being given to the initial design effort, resulting in much faulty hardware. A great effort is then required for subsequent expensive corrective programs which use up our manpower and facilities, and constitute a considerable drain on profits. Not much remains for new programs.

Do Engineers Communicate? Much has been said about the responsibility of the engineer to learn to communicate and to sell his ideas. The Los Angeles conference shows that the engineer knows how to communicate with his own kind as well as can be expected. In fact, the American engineer has no difficulty in communicating with foreign experts. In a supersonic age, he has developed a technical language adequate to express his complex problems. Furthermore, in order for the engineer to do his job well, he must stick to it.

In the meantime, accidents are occurring and people are being killed, while equipment which could prevent these accidents is available or could readily be developed. There are many doubts that our Armed Forces are as well prepared as they could be. This situation is getting worse as our operating speeds increase.

The engineer has developed solutions to most of today's and tomorrow's problems; he is far ahead of the practical application which we see around us.

Those who accept public office and represent the interests of the people, as well as those who assume responsibility for the economic welfare of the nation, certainly must accept some of the responsibility for acquainting themselves with the tools which the engineer is ready to provide to insure a better national life. The engineer's contribution, although basic, is only a part of the over-all job required to put a piece of complex hardware, or an operational system, into service. The creative engineer cannot be expected to drop his demanding technical work and take on all the aspects of the job of finding the ways and means of making these benefits available to the nation.

In the past, both engineering concepts and governmental structures were simpler and it was possible for the engineer to assume the initiative in many nontechnical aspects of the work, as admirably described in Steinman's "Builders of the Bridge." Today in aerospace technology the technical aspects have become much too involved and complex to permit the creative engineer personally also to engage extensively in other than technical aspects of the work.

Herein lies one of the greatest challenges to our political and economic leaders in the space age. On one hand we complain about too many societies and too many technical meetings. Maybe we should welcome this activity, within certain limits, as a real sign of life, as a manifestation of the richness and diversity of technical progress in a free society. It is the result of the awareness in different kinds of engineers of their need to get together to inspire and motivate one another; of the great number of technical specialties clamoring to be heard; of their desire to contribute, to be more effective. It might be a good idea for some of our Congressional Committees to send representatives to our technical meetings to associate directly with creative individuals, rather than to rely on the wisdom of selected consultants.

Aerospace Meetings: Future Plans. The timing of the 1961 Aviation Conference coincided with the ARS Missile and Space Vehicle Conference which was being held at the Los Angeles Hotel Biltmore.

At Marquardt Jet Lab in Van Nuys, Calif., visitors saw engine test facilities capable of simulating operation of full-scale or model engines at extreme speeds and high altitudes

Many engineers walked back and forth between the two hotels, selecting sessions from two program booklets. They liked the idea of attending two meetings with one trip, and we received a number of favorable comments regarding this arrangement. Although there were also a few complaints from men who would have liked to be at two places at one time, the favorable comments greatly outnumbered the negative ones. As a result of this experience, the Aviation Division Executive Committee is considering the proposal that in 1964 and thereafter the national aerospace meetings of the ASME, IAS, SAE, and ARS all be held at the same time and in the same city, at hotels within walking distance of one another. A single registration would permit attendance of any session of the four societies. This arrangement could result in appreciable savings of time and travel expenses for many engineers and their companies.—*John deS. Coutinho*, Mem. ASME, Head, Reliability Control Department, Engineering Division, Grumman Aircraft Engineering Corporation, Bethpage, L. I., N. Y.

Availability List—Aviation Conference

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61—Av-1 Lightweight Thermal Insulation by Transpiration Cooling, by J. G. Krisilas and J. E. Boberg

61—Av-2 Catalytic Filtration of Ozone in Airborne Application, by J. E. Boberg and Myron Levine

61—Av-3 A New Mechanical Approach for the Construction of Modular Electronic Equipments, by R. C. Swengel and W. R. Evans

61—Av-4 The Use of Derivative Pressure Feedback in High Performance Hydraulic Servomechanisms, by T. R. Welch

61—Av-5 Thermal Design for Microminiaturized Circuitry, by H. C. Kammerer

61—Av-6 Forming of Hi-Temperature Metals, by I. J. Wilson

61—Av-7 Measurement of Four Pole Parameters of Complex Structures, by F. B. Safford

61—Av-8 Application of Four-Pole-Parameters of Torsional Vibration Problems, by C. T. Molloy

61—Av-9 Maintainability — A Design Characteristic of Equipment, by J. A. Sahs

61—Av-10 Logistic Supply and Handling of Liquid Helium, by J. W. Marshall

61—Av-11 Design Features of a Cabin Air Turbocompressor for a Transport Airplane, by W. W. Thayer

61—Av-12 Automation in Random Vibration Testing, by Wayne Tustin

61—Av-13 Advanced Fabrication Techniques, by R. Gorcey, J. Glyman, and E. Green

61—Av-14 Integral Pressure-Vessel Welding Techniques—A Review, by L. E. Gatzek and Ivan Rattinger

61—Av-15 Patterns of Failures on Guidance and Instrumentation Equipment, by R. L. Horn

61—Av-16 Gust Alleviation in the Modern Airplane, by G. M. Andrew and F. H. Gardner

61—Av-17 The Disciplined Geometry of Micromodules Yields Practical Miniaturization, by by J. W. Knoll

61—Av-18 A Micromodule Missile Autopilot, by J. H. Porter

61—Av-19 Analysis and Solution of Vibration Problems in the Hughes Model 269A Helicopter, by F. C. Strible

61—Av-20 On the Development of Launchers for Low-Acceleration, Multinozzle Missiles, by A. N. Baxter

61—Av-21 Elevated Temperature Stress-Rupture and Fatigue Properties of Inconel and Inconel X in Ammonia Atmosphere, by M. H. Weisman

61—Av-22 Large Butterfly Valves in the Propulsion Wind-Tunnel Facility at Arnold Center, by J. C. McLane, Jr.

61—Av-23 Optimization Procedures Applied to the Environmental Conditioning System for the B-70 Air Vehicle, by E. W. Adams

61—Av-24 Norair Air Modulator Acoustic Generator, by D. C. Skilling

61—Av-25 Facility Design for Combined Environmental Testing of Rocket Propulsion Components, by R. J. Thoreson

61—Av-26 Missile System Elastomers...Predicting Field Life Expectancies, by J. S. Chandler

61—Av-27 The Ling Model L-200 Vibration Exciter—A Breakthrough in Shaker Development, by J. W. Schreiber

61—Av-28 The Response of Uniformly Damped Cantilever Beams to a Random-in-Time Force, by G. W. Painter

61—Av-29 Mechanical Refrigeration for Lunar Systems, by D. B. MacKay

61—Av-30 Radiant Interaction Between Fin and Base Surfaces, by E. M. Sparrow and E. R. G. Eckert

61—Av-31 A Family of Solar Space Power Systems Based on the Sunflower Concept, by C. J. Daye

61—Av-32 Aircraft Hydraulic Pumps and Motors—New Developments Presage Increased Utility and Application, by F. L. Moncher and R. P. Lambeck

61—Av-33 Heat Transfer Applied to Space Storage of Cryogenic Propellants, by F. R. Cleveland

61—Av-34 On Thermal Stresses in Cylinders Subjected to Gamma-Ray Heating, by N. A. Weil

61—Av-35 Improvement of Fatigue Life of Aircraft Components by Coining, by A. Phillips

61—Av-36 Stability of Honeycomb Sandwich Cylinders, by M. O. Kiciman and D. Y. Konishi

61—Av-37 Explosive Metal Forming Comes of Age, by G. C. Throner

61—Av-38 Calculating Residual Stresses in Some Formed Parts, by C. S. Yen

61—Av-39 An Integrated Cryogenic System for Spacecraft Power, Thrust, and Cooling, by W. L. Burriss and J. L. Mason

61—Av-40 Ausform Steels, Ultra-High Strength Materials for Lightweight Rocket Casings, by S. T. Ross

61—Av-41 Thermal Stress in Circumferentially Constrained Thick-Walled Cylinders and Solid Spheres, by Walter Unterberg

61—Av-42 Evaluation of the Short-Time Mechanical Properties of Structural Beryllium, by E. C. Bernett

61—Av-43 Cavitation Characteristics of Tank Mounted, Centrifugal Type, Cryogenic Pumps, by J. F. Di Stefano and J. O. Panosian

61—Av-44 High-Temperature Alloys for Small Gas-Turbine Application, by M. Kaufman

61—Av-45 A Study of Limitations of Air-Breathing Thermal Engines, by C. A. Sarro

61—Av-46 Development of a Small Gas-Turbine Engine for Helicopter Propulsion, by P. W. Pichel and J. V. Ryan

61—Av-47 A Composite Materials System for Re-Entry Vehicle Applications, by E. D. Weisert

61—Av-48 Vibration Analysis of Small Gas-Turbine Blades, by Rudolph Hohenberg

61—Av-49 Adverse Weather Systems for the Convair 880/990 Jet Transports, by D. T. Bowden

61—Av-50 A Study of Rocket Vehicles Applied to Battlefield Logistics, by S. A. Milliken and H. Nakamura

61—Av-51 Spin and Recovery Simulation of the NAA A3J-1 Airplane on the Human Centrifuge, by R. Z. Snyder

61—Av-52 Design Criteria for a Space Environment Simulator, by A. Lengyel, P. A. Marfone, and D. J. Santeler

61—Av-53 The Influence of Propellant Mass Fraction on Specific Impulse Requirements and Payload Capability of Chemical Rocket Propulsion Systems, by I. S. Florman

61—Av-54 High-Strength, Landing-Gear Forgings—The Manufacture of Ductile Components From Air Melted Steels, by R. L. Roshong

61—Av-55 Discussion of the Design and Operation of the X-15 Environment Control System, by D. G. Westbrook

61—Av-56 Elastic Properties of Orthotropic Monofilament Laminates, by J. C. Ekvall

61—Av-57 Structural Characteristics of Fasteners for Honeycomb, by Jack Cherne

61—Av-58 Application of the Stiffness Method to the Analysis of Shell Structures, by B. E. Greene, D. R. Strome, and R. C. Weikel

61—Av-59 A Comparison of Analytical and Experimental Local Heat Fluxes in Liquid-Propellant Rocket Thrust Chambers, by W. E. Welsh, Jr., and A. B. Witte

61—Av-60 Dynamic Balancing of Missiles and Space Probes, by D. A. Lee and R. J. Switz

61—Av-61 New Joining Processes for Uncommon Materials, by R. E. Monroe

61—Av-62 Molecular and Colloidal Ions for Electrical Propulsion, by A. Lucile Cox

61—Av-63 Development of the T63 Engine, by J. M. Wetzler and W. S. Castle

61—Av-64 The Application of the Gas Turbine to Ground-Cushion Vehicles, by A. P. Kelley and L. W. Norman

61—Av-65 Control of Supersonic Inlets, by T. A. Flanders

61—Av-66 The Efficient Design of Truss-Core Sandwich Plate for Spacecraft, by D. G. Younger, Jr.

61—Av-67 An Economic Analysis of Various Liquid Propellant Booster Systems, by S. F. Iacobellis and H. C. Wieseneck

61—Av-68 The B-52 Towing Tug Hydraulic System—A New Shelf Hardware-Design Concept, by J. O. Byers, Jr.

61—Av-69 Titan Testing, by James Cook

Management simulation games, in which executives, divided into teams, participated in both marketing and manufacturing simulations, were conducted by Univac, a Division of Sperry Rand Corporation. Purpose of the games was to give players the feel of marketing and manufacturing management and a broader perspective by handling various phases of a company operation during a given period of time. Decisions were made on how to handle the sales organization, pay for salesmen, how and when to train personnel, what to spend for advertising and sales promotion, when to order production, where to stock inventory, inventories, raw material purchases, quality control, shipping, etc. Data and decisions were fed into the UNIVAC computer located at the Statler Hilton, processed, and provided statistics and reports as a basis for subsequent action by the executives.

SAM-ASME Engineering Management Conference
Cost-Reduction and Profit-Improvement Session Scores High

More than 600 top, functional, and middle-management executives attended the 16th Annual Management Engineering Conference, sponsored by the Society for the Advancement of Management and the Management Division of The American Society of Mechanical Engineers, at the Statler Hilton Hotel, New York, N. Y., April 6–7. "Improving the Technologies of Managing for Profit" was the timely theme of the Conference.

Cost Reduction. Faced with a sagging economic situation, it was not unusual that nearly 300 attended the "Cost-Reduction and Profit-Improvement" session. They heard A. J. Piacquad of the Curtiss-Wright Corporation emphasize that an effective cost-reduction program requires the blessing and complete support of top management. If the existing management is not cognizant of its importance, he said, the merits and potential of the program must be sold to them. Cost-reduction targets should be assigned to department heads by the general manager. He pointed out that the distribution of cost-reduction targets to all departments serves a dual purpose: First, it assures that cost-reduction proposals will receive co-operation rather than resistance, and second, that the total mass of know-how, experience, and imagination within the company will be utilized.

Dr. Mason W. Gross, ASME luncheon speaker, calls for greater precision and accuracy, particularly in speech education. We are becoming sloppier than ever before in language, he stated.

Mr. Piacquad recommended that a cost-reduction committee be established consisting of members of the major departments. This committee should meet weekly or biweekly and discuss progress and plans for the cost-reduction program. The company-wide representation on the committee would guarantee a technical competence and administrative capacity to discuss and evaluate all types of cost-reduction problems that would be placed before it.

A sound cost-reduction program requires something in addition to the generation, evaluation, and installation of cost-reduction proposals. It must have as an integral part a periodic audit of its executed proposals to determine whether or not the savings claimed on the cost-reduction proposals have been obtained in fact. This audit can be performed by departments within the organization that are staffed with professional personnel having this capability such as auditing, industrial engineering, systems and procedures, and labor measurement. Since cost reduction is aimed at profit improvement, the cost-reduction achievement should eventually leave its impact in the form of reduced appropriations of the operating and manpower budgets and should not, under any circumstances, be dissipated to the point where the savings are eroded over a period of time.

Monthly reports should be prepared by the cost-reduction committee for the general manager and his department managers, he said. These reports measure performance against target and are reviewed individually and collectively by this group in order to insure that continued emphasis is placed on the cost-reduction task. The general manager should review the cost-reduction reports at his regular staff conferences. He must energize the program and promote its significance by a continuing appraisal of its contributions to the total company effort and by elevating its importance as project matter to the level of other company projects such as Sales Engineering and Production.

In other sessions, means to overcome the steady erosion of profits by constantly rising costs were explored, and many new practical ideas and applications, which have been pilot-tested in the field were discussed in talks and technique-oriented workshops.

Conference Luncheons. Besides morning and afternoon sessions on practical improvement of management principles, the conference luncheons featured Allen H. Mogensen, director, Work Simplification Conference, Lake Placid, N. Y., speaking April 6 on "What Management Needs From Industrial Engineering"; and April 7, Mason W. Gross, President, Rutgers—The State University, New Brunswick, N. J., on "An Educator Looks at the Future Needs of Management."

James E. Newsome, production manager, Johnson & Johnson, Chicago, Ill., and president of SAM; and Marshall Anderson, manager, General Purpose Control Department, General Electric Company, Bloomington, Ill., and chairman of the ASME Management Division, served as chairmen, respectively, of the luncheon meetings.

At the April 6 luncheon the Lillian M. Gilbreth Medal was awarded to Gerald D. Nadler, PhD, head, Industrial Engineering Department, Washington University, St. Louis, Mo.; and the Material Handling Award was presented to Charles S. Schroeder, director of Research and Development, Yale and Towne Manufacturing Company, Philadelphia, Pa.

Presentation of ASME Awards took place at the April 7 luncheon. Mr. Anderson presented an ASME Fellow certificate to Eugene Henry MacNeice, director of Quality Control at Johnson & Johnson, New Brunswick, N. J. A special citation was awarded to David B. Porter, professor-emeritus, Industrial Engineering, New York University, in recognition of his pioneering in motion-study education, his advocacy of work simplification, and his service to scientific management.

Dr. Gross, principal speaker at the ASME luncheon, declared that the manager of the future needs high technical competence that can change and grow with the times. To turn out graduates to fill management gaps, Dr. Gross indicated that curriculums must stress the following: (*a*) Flexibility, (*b*) precision and accuracy, and (*c*) creativity.

ASME Award Presentations: Marshall Anderson, **center,** congratulates David B. Porter, **right,** on receiving special ASME citation as Eugene Henry MacNeice, who had just been made a Fellow of ASME, looks on

ASME Textile Conference Draws 200 for Discussion of Industry Problems

TEXTILE engineers discussed details of the newest developments in the textile industry during the two-day ASME Textile Engineering Conference at Clemson College, Clemson, S. C., March 16–17. About 200 attended.

Gathering at Clemson House on a hill overlooking the campus, the engineers were welcomed by Dr. James H. Sams, Fellow ASME, and then spent the better part of the first day in a lively panel discussion on the potential of "nonwovens," fabrics made of cemented fibers. The subject was so popular, it kept panelists busy all morning, then lured them back after lunch. At dinner that evening, guest speaker Dr. Walter Lowry, Jr., dean of the Clemson School of Engineering, told the textile men that schools of the future must be aware of the changing needs in engineering education.

The shuttleless loom, one of the industry's revolutionary innovations, claimed the spotlight during the morning session on March 17. This new type of loom, lately introduced to commercial practice, employs methods other than the conventional shuttle to pass the "filling" or weft through the "shed" or raised warp yarns. Several methods were presented in the papers. "The Shuttleless Loom," by A. E. McKenna, of the School of Textiles, Clemson College; "The Maxbo Shuttleless Loom," by R. J. Farr, Edda International Corporation, New York City; and "The Draper Shuttleless Loom," by J. D. Marshall, Draper Corporation, Spartanburg, S. C. The Maxbo loom, developed in Sweden by an Estonian engineer, weaves thread with compressed air. The Draper loom does it with the aid of flexible steel tapes or rapiers on each side of the cloth that meet in the middle to transfer the thread from one side to the other. Papers on cotton production also presented were: "Cotton—Mechanics of Ginning and Effects in Quality," by J. A. Luscombe, U. S. Department of Agriculture, Southeastern Cotton Ginning Research Laboratory, Clemson; and "Cotton—Some Aspects of Quality as Related to Manufacturing," by J. E. Ross, Agricultural Marketing Service, U. S. Department of Agriculture, Clemson.

Two industrial tours taken the first day of the meeting provided a first-hand look at the manufacturing of textile machinery in the Saco-Lowell Research and Development Center and the Saco-Lowell Easley Plant and demonstration area, Clemson; and an introduction to the Clemson College School of Textiles and the U. S. Department of Agriculture Pilot Spinning Plant and Ginning Laboratory.

Availability List—Textile Engineering Conference

THE papers in this list are available in separate copy form until Jan. 1, 1962. Please order only by paper number; otherwise the order will be returned. You can save the postage and handling charges by including your check or money order made payable to ASME with your order and sending both to the ASME Order Department, 29 West 39th Street, New York, 18, N. Y. Papers are priced at 50 cents each to members; $1 to nonmembers. Payment also may be made by free coupons distributed annually to members, or coupons which may be purchased from the Society. Coupons, in lots of ten, are $4 to members, $8 to nonmembers.

61—Tex-1 Cotton—Mechanics of Ginning and Effects on Quality, by J. A. Luscombe

61—Tex-2 The Maxbo Shuttleless Loom, by R. J. Farr

61—Tex-3 The Shuttleless Loom, by A. E. McKenna

61—Tex-4 Cotton—Some Aspects of Quality as Related to Manufacture, by J. E. Ross

Underwater Technology Group Formed by ASME

THE tremendous increase in interest and activity connected with the ocean environment has raised many new problems and areas of activity of interest to mechanical engineers. In recognition of this, the Council of the ASME approved, on April 14, the formation of an ASME Professional Group on Underwater Technology. Chairman of the Group is Richard Neuendorffer of the New London Section, ASME.

Objectives. The Group, newest of ASME, has the following objectives: (*a*) To constitute a Professional Group of ASME in the field of underwater technology; (*b*) To promote the art and science of underwater technology in mechanical engineering; (*c*) To encourage and foster research and development and the publication of significant data and original research within the scope of the Group's activities; (*d*) To encourage the interchange of ideas among engineers by means of the following methods—the preparation and publication of papers on engineering developments; organization of programs in which papers in the field of underwater technology are discussed; and cooperation with other Professional Divisions within the Society with respect to standardization, research, preparation of papers, meetings, and special services.

The Executive Committee of the Group is headed by Richard Neuendorffer as Chairman. Neuendorffer is Supervisor, Research and Development Department, Electric Boat Division, General Dynamics Corporation, Groton, Conn. Other members are John Craven, Bureau of Naval Weapons, Washington, D. C.; George Wislicenus, Ordnance Research Laboratory, Pennsylvania State University, University Park, Pa.; H. Norman Abramson, Director of Department of Mechanical Sciences, Southwest Research Institute, San Antonio, Texas, Secretary of the Group; and Cmdr. Arnold Medbury, Bureau of Ships, Washington.

Underwater Technology Symposium

The Executive Committee of this Group has acted swiftly in formulating plans for the 1961 ASME Winter Annual Meeting. A symposium definitely is planned which will deal primarily with the objectives and future of "Underwater Technology" as outlined by several invited authorities in various areas of this field. It also has planned to hold a luncheon with an invited speaker and to have an additional technical session based on contributed papers. The Group also intends to distribute a Newsletter at regular intervals throughout the year to keep members of the Society informed concerning its activities.

The general fields of interest of the Group will center around all mechanical engineering problems which relate to vehicles, devices, operations, and the like, underwater and at the interface. Some ideas and problem areas relative to mechanical engineering objectives of underwater technology are illustrated.

President Spurs National Program

Formation of this Underwater Group is especially timely in view of President John F. Kennedy's recent request for $97 million to spend in research on "the seas around us." President Kennedy asked for $97,501,000 for numerous projects in oceanography including development of future sources of food and minerals, weather forecasting, weather control, as well as the gathering of new facts useful to the Navy in undersea operations.

"We are just at the threshold of our knowledge of the oceans," Mr. Kennedy said in a letter to Vice-President L. B. Johnson. "Knowledge of the oceans is more than a matter of curiosity. Our very survival may hinge upon it.

"The seas offer a wealth of nutritional resources. They already are a principal source of protein. They can provide many times the current food supply if we but learn how to garner and husband this self-renewing larder. To meet the vast needs of an expanding population, the bounty of the sea must be made more available. Within two decades our own nation will require over 1,000,000 more tons of seafood than we now harvest."

The President said: "This is not a one-year program or even a ten-year program. It is the first step in a continuing effort to acquire and apply the information about a part of our world that will ultimately determine conditions of life in the rest of the world."

Among the things the proposed $97,501,000 would be spent on in the next fiscal year would be ten new oceanographic vessels, laboratories, wharfside facilities, and basic research.

ASME's Underwater Technology Group therefore should find much in common with the governments plan for studying the oceans.

Artist's drawings depict but two of the many projects of interest to the recently formed Professional Group on Underwater Technology. The Aluminaut, **left,** is a deep-diving submarine in the final planning stages. The vehicle will operate at depths far exceeding contemporary vessels. It will carry an observation crew of two and one operator. **Right photo** shows a military submarine.

Conducted for the National Junior Committee

J.W. FOLLANSBEE[1]

JUNIOR FORUM

Books to Read and Things to Do

A Word About Books

SOMETIMES I think that among the million or so categories in which one finds himself, among all these are two labeled "readers" and "nonreaders." If you're a reader, there's nothing you can do about it. You're born that way. And if you're a nonreader, don't fret. That's the way you started, and that's the way you'll end.

No persuasion, no dissuasion, no coaxing, cajoling, pleading, beating, ranting, raving, logic, illogic—nothing can change this course of life. So, when you set out to extol the benefits of books, it's really pointless.

For, you see, the readers think you're an idiot for trying to get them to do something they're already doing. And the nonreaders think you're an idiot for wasting good pulpwood. Nevertheless, there are times when it's fun to be an idiot. And this is one of them.

I've labored over many a "read this so you will be well-read" book list. Most of them seem designed to turn educated men into illiterates, and nonreaders into cretins. So I'm more than just pleased at the chance to report a list of books that, though labeled "Selected Reading for Young Engineers," would make a good reading list for anyone of any age. Most of the list consists of nonclassics. The point being the committee that comprised the list think most engineers will be acquainted with the great and familiar works of literature and religion. Therefore books on the list in question are aimed at opening up the territories of human achievement and at interesting the young engineer in fields that may be explored with attendent cultural profit.

The list, covered in a slender eight-page ECPD pamphlet, covers ten general areas of thought, type of literature, and endeavor. Several are classics, in case you missed a few along the way, and several were authored after 1950. Get this pamphlet. Use it as a bookmark, then it will always be handy. It costs 15 cents and you can get it (Selected Reading for Young Engineers) at the Engineers' Council for Professional Development, Training Committee, 29 West 39th Street, New York 18, N. Y.

One more thought on this general subject. From time to time one hears about speed-reading courses and the many benefits that they offer. Yet few of us do anything about it. I recently witnessed a demonstration in which a secretary, formerly of normal reading speed, read—in 40 seconds—ten pages of a book she had never seen. Her reading speed varies between 3000 and 6000 words per minute. She got up to this pace after a 12 week speed-reading course.

Reading speeds in this range mean she can read a 300-page novel in say, including minor interruptions, between 45 minutes and an hour and a half. After reading the ten pages, this young woman gave a discussion of what she had read that indicated she got comprehension and understanding as well as retention along with her speed. The point of bringing this up is that the press of time prevents many people from reading. With increased reading speed, more time could be devoted to reading of all sorts, and most likely there would be much less resistance to reading. (For instance, a person would get more from the newspaper. You would read more of it and more often, since you could read the whole thing, excepting the stock page, in about 15 minutes or less.) If you would like information about speed reading, including how it affects technical reading, write in and say so. If you show enough interest, I'll dig around and see what's available in formal as well as do-it-yourself courses and books and also try to get critiques from people in various fields who use this reading technique.

Regional Activities: Thing to Do

The National Junior Committee is made up of people. It in turn has developed a committee, also made up of people, with the above title that handles activities on the Regional level. The problem here usually is that the most important people—the young engineers and members—don't know who the committee people are in their local areas. So, now and then, we post you on who is presently heading up committee activities. Here, on a Region by Region rundown, are the men to contact in your areas if you are interested in the goings on of the Associates Committee.

Region I. Covers all of New England. For information on a newly formed RAAC in this area, write to Sam Merraat, Arthur D. Little, Inc., Acorn Park, Cambridge, Mass.

Region II. This takes in metropolitan New York and all of New Jersey. At the moment there is no RAAC hereabouts. Bernard Meany has volunteered, and the National Junior Committee is depending on him, to spark the formation of the activities committee in this Region. Does he need help!

International Current-Meter Group Formed

THE current-meter technique of flow measurement was one of the earliest established methods for metering large rates of flow and one of the first to be accepted by the various national and international test codes. However, certain aspects of current-meter performance and calibration procedure need clarification, a goal toward which researchers have worked for a number of years. To co-ordinate this research, representatives from seven countries founded the International Current-Meter Group (ICMG), in 1959. Under the chairmanship of Professor Gerber of the Swiss Federal Institute of Technology, Zurich, they established a research and development program. Members meet annually to review progress and to discuss the results, which are published by the National Engineering Laboratory at East Kilbride. Delegates to these meetings are interested in receiving information on current-meter performance or measurements of unusual interest. Contributions should be addressed to Dr. F. A. L. Winternitz, Secretary—ICMG, National Engineering Laboratory, East Kilbride, Glasgow.

[1] Designer, Voorhees, Walker, Smith, Smith & Haines, New York, N. Y. Assoc. Mem. ASME.

And, Bernie is more than willing to share the work and the credit for forming an associates committee in Region II. He is with Federal Systems Division, IBM Corporation, Neighborhood Road, Kingston, N. Y.

Region III. Includes Upstate New York, Eastern Pennsylvania down to Washington, D. C. This area, as Region II, contains large metropolitan centers, yet still contains no active RAAC. Those of you living in Region III interested in an active activities group contact Bob Heinzman, Therm Inc., Ithaca, N. Y.

Region IV. Paul Halyard of the Maddox Founldry and Machine Works, Archer, Fa., is a new member on the Nationa Junior Committee and also is workingulp a Region IV Activities Committee. Roy C. Robertson, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ASME Region IV Vice-President, is also eager to form an associates committee in the Region. If you live in the Southeast U. S. contact either of these men. You'll get a good response.

Region V. Ohio, West Virginia, Western Pennsylvania, and Central Michigan. Here our contact is John Dougherty, T. J. Barry Company, Park Building, Pittsburgh 22, Pa. As of this writing the RAAC is part of this Region's Membership Committee. And, a study is going on to find if an RAAC is needed in the Region. Unless the study turns up plenty of interest, there most likely will be no RAAC formed here. If you're young and virile and want a voice in both ASME and your profession, write to John Dougherty of your interest. Otherwise, forget it.

Region VI. This territory wanders all over the Midwest, east of the Mississippi, extending from St. Louis up to Minnesota, and includes Chicago and Louisville. Here we find the present bright spot in RAAC activities. A strong, active group has been functioning for several years. Presently, Edwin Mendenhall, Allison Division, General Motors, 5442 University Avenue, Indianapolis, Ind., is chairman. Write to Ed for ideas about this group.

Region VII. Encompasses seven states found on the banks of the Missouri and Red Rivers from Kansas City north. The simplest way to find out about your Region's activities here is to write to Merle E. Jansen, Central Electric & Gas Company, 144 South 12th Street, Lincoln, Neb.

If you live in any of the remaining Regions, taking in the Mountain States, the Southwest or the West Coast, and are interested in information concerning the Regional Associates Activities Committee, what it does, how to form a local branch, or other questions, get in touch with Paul R. Beswick, Secretary of the National Junior Committee, ITL Division, Itek Corporation, Lexington, Mass.

ASME Boiler and Pressure Vessel Committee Meets in Charlotte, N. C., March 12—17

THE Boiler and Pressure Vessel Committee of The American Society of Mechanical Engineers met jointly with The National Board of Boiler and Pressure Vessel Inspectors in Charlotte, N. C., March 12 to March 17, inclusive, for its yearly out-of-town conference at the Barringer Hotel.

Marcus B. Cortts, chairman of the ASME Piedmont-Carolina Section welcomed the conference to Charlotte; this was followed by addresses by the Hon. James Saxton Smith, Mayor of Charlotte; the Hon. Frank Crane, Commissioner of Labor of the State of North Carolina; and the Hon. Thad Eure, Secretary of the State of North Carolina.

Several of the subcommittees held meetings during this session, including the Subcommittees on Power Boilers, Heating Boilers, Unfired Pressure Vessels, as well as the Special Committee on Nuclear Power. These were followed the next day by the Main Committee meeting of the Boiler and Pressure Vessel Committee. The meetings were open to the public. Earlier in the week, conferences were held of The National Board of Boiler and Pressure Vessel Inspectors.

One of the high points of the meeting was the presentation at the banquet Wednesday evening of certificates of promotion to Fellow grade in ASME to H. E. Aldrich, chairman of the Boiler and Pressure Vessel Committee, and to C. O. Myers, executive director of The National Board of Boiler and Pressure Vessel Inspectors. Roy C. Robertson, ASME Region IV Vice-President, was present to congratulate Messrs. Aldrich and Myers.

Another high light of the meeting was a group visit to the Allen Steam Station of the Duke Power Company in Belmont, N. C. This is a relatively new plant in partial operation since 1957, and it is expected to be operating at full capacity at the end of 1961 with the completion of its fifth power unit. W. B. Freeman, plant superintendent, and R. W. Olive, manager of steam production, a member of the Boiler and Pressure Vessel Committee Subcommittee on Power Boilers, were responsible for this excellent tour.

The ASME Boiler and Pressure Vessel Committee and The National Board of Boiler and Pressure Vessel Inspectors is indeed grateful to Region IV, Piedmont-Carolina Section, and the untiring efforts of the Planning Committee. S. F. Harrison, chief boiler inspector of the State of North Carolina, representing The National Board of Boiler and Pressure Vessel Inspectors, served as chairman of the Planning Committee, and was assisted by co-chairmen W. H. Owen, for the ASME Piedmont-Carolina Section, and H. A. Maynard and M. W. Tall.

ASME CODES AND STANDARDS WORKSHOP

Obituary

H. E. HALLER passed away on Feb. 13, 1961. Mr. Haller was President of the National Valve and Manufacturing Company, 3101 Liberty Avenue, Pittsburgh 1, Pa.

Errata

"ASA B1.5-1952, Acme Screw Threads." The following errors have been called to our attention: In table 21, page 33, in the last column (5" Nom. Dia, 2 tpi), Internal Threads: Classes 5C and 6C, Major Dia, min, change 4.4963 to 4.9463; Class 5C, Major Dia, max, change 4.5041 to 4.9541; Class 6C, Major Dia, max, change 4.5008 to 4.9508.

The Errata Sheet, dated February, 1961, for B5.16–1960, Involute Splines, Serrations and Inspection, has been published and is available from the Order Department, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

May 7–10, 1961
ASME-EIC Hydraulic Conference, Queen Elizabeth Hotel, Montreal, Que., Canada

INTERNATIONAL CONFERENCE ON CREEP AND FRACTURE

August 25–28, Hotel Biltmore, New York, N. Y.

SPONSORED by The Institution of Mechanical Engineers (British), The American Society of Mechanical Engineers, and the American Society for Testing Materials, the 1963 International Conference on Creep and Fracture, August 25–28, Hotel Biltmore, New York, N. Y., will present new ideas and information, and evaluate existing literature on the elevated temperature mechanical properties of engineering materials. The proposed categories of papers that are to be considered for this conference are:

A Fundamentals of Creep and Fracture

1 Mechanisms—Atomistic, dislocation, material or metallurgical structure, etc.

2 Plasticity Theory in Creep—Theoretical and experimental studies in uniaxial or combined stresses.

3 Studies in relaxation, thermal and mechanical cycling, rapid and dynamic creep.

B Design Techniques for Creep and Fracture

1 Criteria for design—Uniaxial and combined stress, thermal and mechanical cycling, relaxation, and creep behavior of Composite Materials.

2 Application and interpretation of creep and fracture data—information concerning particular materials short and long time tests and extrapolation of data

C Service Experience in Creep and Fracture

1 Correlation of service data with laboratory tests and methods of testing.

2 Environmental effects—oxidation, corrosion, ablation, erosion, radiation, etc.

Offers of papers for this conference must be received no later than April 1, 1962, by: Mr. N. L. Mochel, Conference Secretary, Westinghouse Electric Corporation, Steam Division, Lester Branch P. O., Philadelphia 13, Pa.

ASME COMING EVENTS

May 8–9, 1961
Lubrication Symposium, Deauville Hotel, Miami Beach, Fla.

May 10–12, 1961
ASME Production Engineering Conference, Royal York Hotel, Toronto, Ont., Canada

May 22–25, 1961
ASME Design Engineering Conference and Exhibit, Cobo Hall, Detroit, Mich.

June 11–14, 1961
ASME Summer Annual Meeting, Statler Hilton Hotel, Los Angeles, Calif.

June 14–16, 1961
ASME Applied Mechanics Conference, Illinois Institute of Technology, Chicago, Ill.

June 19–21, 1961
Heat Transfer and Fluid Mechanics Institute, University of Southern California, Los Angeles, Calif.

August 28–30, 1961
ASME West Coast Conference of Applied Mechanics, University of Washington, Seattle, Wash.

August 28–September 1, 1961
Second International Heat Transfer Conference, University of Colorado, Boulder, Colo.

September 14–15, 1961
ASME-AIEE Engineering Management Conference, Hotel Roosevelt, New York, N. Y.

September 24–27, 1961
ASME-AIEE National Power Conference, St. Francis Hotel, San Francisco, Calif.

September 24–27, 1961
ASME Petroleum Mechanical Engineering Conference, Muehlebach Hotel, Kansas City, Mo.

October 4–6, 1961
ASME Process Industries Conference, Shamrock Hilton Hotel, Houston, Texas

October 17–19, 1961
ASME-ASLE Lubrication Conference, Morrison Hotel, Chicago, Ill.

November 26–December 1, 1961
ASME Winter Annual Meeting, Statler Hilton Hotel, New York, N. Y.

(For Meetings of Other Societies, see page 124.)

Note: Persons wishing to prepare a paper for presentation at ASME National meetings or Division conferences should secure a copy of Manual MS-4, "An ASME Paper," by writing to the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Price to nonmembers, 50 cents; to ASME members, free. Also available on request is a "Schedule of Program Planning Dates for Meetings and Publication Deadline Dates." Ask for Form M&P 1315.

ACTIONS ASME EXECUTIVE COMMITTEE

A MEETING of the Executive Committee of the Council was held in the rooms of the Society on Friday, March 3, 1961. There were present: W. H. Byrne, President; D. E. Marlowe, H. N. Muller, L. N. Rowley, and R. B. Smith of the Executive Committee; W. H. Larkin, Director; G. B. Thom, Vice-President; E. J. Kates, Treasurer; O. B. Schier, II, Secretary; W. E. Reaser and J. D. Wilding, Assistant Secretaries; H. I. Nagorsky, Controller; and D. B. MacDougall, Associate Head, Field Service.

Council. *Resignation.* The council accepted with regret W. H. Larkin's resignation as a Director of the Society effective April 1, 1961, when he will become a member of the ASME Staff, and extends best wishes and success in his new endeavors.

ASME Organization. *Study.* The Secretary reported that a meeting of the Ad Hoc Committee on the Study of the Society would be held early in March to permit a representative of Cresap, McCormick and Paget to review the draft of their final report. The final report should be available to the Organization Committee and the Council early in April.

Member Gifts Campaign. *Report.* W. H. Larkin summarized the progress of the Society in its Member Gifts Campaign since Feb. 3, 1961.

Tripartite Committee on Co-Ordination of Policies Relating to Private Practice of Engineering. *ASME Representation.* The Council approved the appointment of a representative to the Tripartite Committee on Co-ordination of Policies Relating to Private Practice of Engineering.

ASME Emblem. *Permission to Use.* The Council authorized the use of the ASME emblem on the cover of the brochure being prepared by the New York State Department of Commerce tentatively entitled "Keys to the Future —Research and Development in New York State."

Fulton Monument. *Repair.* The Council voted to have Vice-President Thom request Harry R. Kessler to check the cost of such work as would be required to reinscribe the line on the bronze drawing of the Steamship Claremont on the Fulton Monument.

Niels Bohr International Gold Medal. *1961 Award.* The Council approved the nomination of Dr. Edward Teller for the 1961 Niels Bohr International Gold Medal presented by the Institution of Danish Civil Engineers for outstanding work for the peaceful utilization of atomic energy.

Certificates of Award. *Rubber and Plastics Conference.* The Council authorized the presentation of a certificate of award to George H. Billman of the Erie Section for outstanding efforts for the 1960 Rubber and Plastics Conference.

Retiring Section Chairmen. Certificates of award have been prepared for the following 1959–1960 Section chairmen: Marshall E. Bishop, Mid-Hudson; Alfred F. Bochenek, Washington, D. C.; Leonard D'Ooge, San Francisco; Albert H. Figg, Canton-Alliance-Massillon; George W. Marshall, Florida; Peter W. Meyer, Western Massachusetts; Richard Neuendorffer, New London; Lawrence A. Platt, Kansas City; Calvin E. Redfern, Oregon; Thomas V. Reinaurer, Mid-Jersey; and C. L. Tansil, Jr., Sabine; and Marvin J. Moseley, Paducah Subsection of the Louisville, Section.

Appointments. *Presidential.* E. J. Carraro, Washington Award Dinner, March 2, 1961, Chicago, Ill.; W. F. Ryan, The Massachusetts Institute of Technology Centennial Convocation, April 9, 1961; and J. M. Todd, Inauguration of Tulane Univeristy President, April 15, 1961, New Orleans, La.

ENGINEERING SOCIETIES PERSONNEL SERVICE, INC
[Agency]

THESE items are listings of the Engineering Societies Personnel Service, Inc. This Service, which co-operates with the national societies of Civil, Electrical, Mechanical, and Mining, Metallurgical and Petroleum Engineers, is available to all engineers, members or nonmembers, and is run on a nonprofit basis.

If you are interested in any of these listings, and are not registered, you may apply by letter or résumé and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee. Upon receipt of your application a copy of our placement-fee agreement, which you agree to sign and return immediately, will be mailed to you by our office. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application.

NEW YORK
8 West 40 St.

CHICAGO
29 East Madison St.

SAN FRANCISCO
57 Post St.

Men Available

Chicago Office

Project Manager, BSME; 42; ten years experience in heavy chemical-plant utilities and process design; four years development and design of construction equipment. Economic evaluations, co-ordination of all phases of projects, planning, and scheduling. $10,500. West or Midwest. Me-2133-Chicago.

Mechanical Engineer, BSME; PE; 32; 11 years' experience in production-plant engineering including layout and fabrication of materials-handling equipment, R&D, and materials handling for a chemical plant. $10,000. East, Midwest. Me-2145-Chicago.

Project Manager, BSME; 36; three years' experience co-ordinating design and fabrication of unique nuclear and space-age components plus ten years R&D field engineering in heavy equipment provides ability to direct your unusual projects and meet specifications, schedules, and estimates. $9500. U. S. Me-2146-Chicago.

Chief Engineer, BSME; 53; 32 years' experience in engineering design and maintenance field, rolling mills, brass and steel; also plant engineer. $20,000. Chicago area. Me-2147-Chicago.

Director of Engineering, Chief Engineer, Plant Manager, BSCE; 34; successful engineering and/or plant management in firms producing dishwashers, disposers, clothes dryers, air conditioners, professional furniture, commercial, and residential lighting fixtures. Broad administrative experience in product development, production engineering, cost-reduction activities. Ten years' responsible supervisory experience. $18,000. Immaterial. Me-2148-Chicago.

Recent Graduate Mechanical Engineer, June, 1961; 28; Veteran, married, prefers position in air-conditioning or refrigeration field. Eight years' experience in air-conditioning and refrigeration service and installation. Attended air-conditioning and refrigeration school; also two years as machinist apprentice. One summer in industrial-planning department. Prefers Midwest, but will go anywhere. Me-2149-Chicago.

Maintenance Staff Engineer on Division or Plant Level; Superintendent of Maintenance or Consultant; BSME; 35; experienced in all phases of equipment and facilities design, construction, and maintenance in the chemical and processing industries. Specialized in introduction of preventive maintenance, maintenance upgrading, and cost reduction. $13,000. East, Midwest, South. Me-2150-Chicago.

Chief Engineer or equivalent, BSME; 38; 17 years' varied experience in design and development; nine years in responsible charge of all engineering on extensive product line major manufacturer of light to heavy mechanical equipment. Licensed. $13,500. Will relocate. Me-2151-Chicago.

Mechanical Engineer, BSME; 29; three years' experience in designing aluminum and steel-mill equipment; seven months in R&D department for structural steel company. Open. Midwest, South, and West. Me-2152-Chicago.

Chief Engineer or Production Manager, BSME, MBA-Industrial Management; 38; 14 years in production engineering, machine design, tooling, automation, and management. Responsible for planning of products through R&D to the finished article. Product lines include stable platforms, gyroscopes, metal stampings, appliances, and electromechanical devices. Six years' experience engineering supervision. $13,000. Midwest. Me-2153-Chicago.

Mechanical Engineer, BSME; 30; three years' experience with consulting-engineering firm designing heating, ventilating, air conditioning, and plumbing systems; six months' experience in plant engineering for large smelter. $7000, minimum. Western U. S. Me-2154-Chicago.

Chief Mechanical Engineer, BSc, ME; 38; 13 years' experience consulting, contracting, heavy construction. $10,000–$12,000. Chicago. Me-2155-Chicago.

New York Office

Sales Manager, Military Liaison Sales, ME, 1948; 12 years' experience military design, sales, contract administration, field-engineering services. Currently manager of military sales. $12,000. West, South, New England. Me-930.

Design and Development Engineer, BS (ME); 6½ years' experience in development engineering; two years chief engineer in charge of design and development, metal fabricating. Holds patent, PE license. Prefers design of mechanisms. $9600. East or West. Me-931.

Chief Engineer, Engineering Manager, graduate mechanical, 20 years' experience in management, sales, and design of automatic machinery and machine tools. Proved creative leadership and management abilities. Desires change for greater challenge and growth. $18,000, minimum. Continental U. S. Me-932.

General Manager or Director of Engineering, MS CE; 25 years' experience in heat-transfer field including assignments as general manager, chief engineer, and sales manager. Thorough knowledge of power, petroleum, and chemical equipment. Open. Immaterial. Me-934.

Representatives of engineering societies at the annual meeting of the San Francisco Advisory Committee of Engineering Societies Personnel Service, Inc. Seated, **left to right,** are: Eric Salo, Mem. ASME, newly elected chairman; Bennet L. Raffin, ASCE, retiring chairman; E. V. Noe, AIEE; and A. H. Meyer, executive director of ESPS. Standing, **left to right,** are: Lauress L. Wise, ECSF; Heino Jogis, ASCE; W. Carl McCulloch, AIME; Morris Weitzner, SNAME; and Joseph R. Decker, manager of the San Francisco office of ESPS.

[1] All men listed hold some form of ASME membership.

Mechanical Engineer, BME, MScME, E.I.T. lic.; 25; three years' experience teaching, development, research. Desires position in consulting, development, or technical administration. Prefers foreign or New England, but will consider relocating anywhere. Me-935.

General Manager, Vice-President, Sales, mechanical graduate, extensive experience major oil company in sales, requisitions and spin-offs, budgets, market research, cost reduction and control, and distribution. Also experience in consulting engineering, and design and production experience in mining and aircraft industries. $20,000. Northeast. Me-937.

Maintenance Engineer, BSME; varied experience with oil companies in project and maintenance engineering. Knowledge of foreign nationals and ability to work with them. Travel no objection. $10,000. Foreign. Me-938.

Mechanical-Design Engineer, six years University Extension; ten years' experience in mechanical field including: Research, development, mechanical design, electrical design, technical writing, sales, field engineering, and purchasing. Registered PE. $8000, minimum. R. I. Me-939.

Chief Engineer, graduate mechanical, 1½ years as applications engineer on specialized gearing; 12 years R&D pertaining to portable electrical tools; 1½ years specialized die casting liaison; four years' shop foreman. $15,000. Middle Atlantic States. Me-940.

Plant Manager-Chief Engineer, BME; 20 years' diversified experience engineering and management ranging from textiles, underwater sound, ultrasonics, and manufacture of vinyl plastic sheeting. Wide experience in basic research, machine design, process industries. $15,000. Metropolitan N. Y. area, Westchester County. Me-941.

Chief Engineer, valve manufacturing, BSChE; 14 years' experience in design and development of valve products and specialties including hand operated, control, ball, plug, regulator, and relief valves. $15,000. East Coast. Me-942.

Production-Management Engineer, BME 1950, 28 credits toward MBA; heavy thermoplastics and rubber processing. $10,000 minimum. East. Me-943.

Mechanical Engineer, MME; 20 years' design/development of automatic and process machinery including board layouts, shop drawings, and field installations. $10,500. Metropolitan New York. Me-944.

Plant, Maintenance and or Construction Engineer, BSME; 32 years' wide experience in all these fields, acknowledged administrator, large or small plants and constructions, all utilities, powerhouses, heating, ventilating, conditioning, equipment, liaison, management, etc. $10,000. U. S. A. Me-945.

Plant Superintendent or Engineering Manager, BSME; nine years' experience in $100 mm metallurgical plant, operations and maintenance ore drying-grinding equipment, reduction furnaces, gas producers, also design and construction. Business experience independent engineering, consulting, and agricultural venture. Fluent English and Spanish. Open. Immaterial. Me-946.

San Francisco Office

Sales Engineer, ME, 44. Sales experience in aluminum, cutting tools, industrial-process controls. Prefers San Francisco Bay area or West Coast. Home: Conn. $12,000. Se-1451.

Plant Engineer, ME; 36. Ten years' varied plant-engineering experience in heavy industry including plant layout, construction, building maintenance, plant utilities, machinery layout, cost estimates, specification writing, purchasing practices. Prefers Southwest U. S. Home: Md. Se-1427.

Chief Engineer, ME; 45, 14 years' experience in oil, gas, related including pump stations, power-station buildings, piers and marine loading equipment, mechanical engineer on field construction of utilities and prices. Fluent Spanish. Prefer Central, South America. Home: Venezuela. Se-1358.

Sales Engineer, mechanical; 43; 15 years' experience selling various types of mechanical equipment and supplies including process machinery for chemical and metallurgical industries, jet and turbine pumps, mechanical agitators to wholesalers, retailers, and industrial users. Prefers San Francisco Bay area. Home: Calif. $700. Se-1346.

Plant, Production Engineer, ME; 37. Seven years' supervisory experience including development of new products, field operation and development of equipment, maintenance, safety co-ordinator, quality control, design co-ordinate installation, and operation of projects in metal products. Prefers Northwest, West. Home: Wash. $850. Se-1314.

Project Engineer, mechanical; 34. Knowledge of design and construction of equipment and plants. Three years' experience supervising sales, engineering, liaison plant and customer on technical problems, design conveyers, handling systems, weldments, pressure vessels, heat exchangers, estimate cost of production and accessory purchases. Experience in design layouts and arrangements for new and revised equipment, evaluate equipment, and assist in selection and writing of equipment specifications. Prefers San Francisco area. Home: N. Y. $10,000. Se-1273.

Specification Writer, ME; 53. Experience includes contract purchases of technical and engineering facilities, engineering releases, material control. Any location. Home: Calif. Se-1290.

Sales Engineer, ME; 29. Experience in design of mechanical components on airborne electronic countermeasure equipment. Four years' sales experience. Prefers San Francisco Bay area. Home: Calif. $9000. Se-1267.

Production Manager, ME; 44. Managerial experience in design of fire alarm systems, computors, new industrial products. Prefers San Francisco Bay area. Home: Mich. $11,500. Se-1264.

Director, 48; reg. P. E. in Calif.; 21 years' administrative experience and executive ability in valves, measurement, control and safety devices, tank equipment, hydraulic, pneumatic devices, and other industrial pipeline equipment related to petroleum, gas, marine, chemicals, power, sewage, and nuclear atomic power. Supervisory experience includes creating, design, metallurgy, R&D, all phases of manufacturing, specifying and approving machine tools, purchasing, material control, production planning and scheduling, and manufacturing operational costs and selling prices. Any location. Home: Calif. $500. Se-1250.

Sales, Maintenance, 37, 15 years' experience in sales, maintenance and production. Past three years in industrial sales of machine tools, precision inspection, and tooling equipment. Prefers San Francisco Bay area. Home: Calif. $650–800. Se-1245.

Plant Engineer, ME; 38, 11 years' experience including industrial maintenance and construction, cost-reduction programs, establish process labor and materials studies. Prefers San Francisco Bay area or Northern Calif. Home: Calif. $14,000. Se-1221.

Sales Administrative, ME; 46. Over seven years' experience in sales, engineering, administrative, and management in sales training, organizing, staffing, directing, supervising sales force. Prefers San Francisco Bay area. Home: Calif. $12,000–$20,000. Se-1220.

Junior Engineer, ME; 24. Three years' experience as Air Force civil engineer. One year each as planning, construction, and maintenance engineer. Some experience as student engineer in steam-power plant. Prefers West Coast. Home: Calif. $575. Se-1215.

Sales Engineer, ME; 31. Two years' experience in sales, preparation quotations, and submittal of data on performance, maintenance, installation, and use of equipment; assisted in special design problems on industrial heat, ventilating equipment. Prefers San Francisco Bay area. Home: Calif. $8000. Se-1205.

Production, Maintenance Engineer, 58, 30 years' experience in planning, production, and maintenance including steam-electric plants, maintenance of streets, sewage, water, electrical, and fire protection systems. Prefers San Francisco Bay area. Home: Calif. Se-1196.

Sales, Design, Estimating, ME; 46. Over three years' experience in design, drafting, specifications, estimating, bidding, sales, purchasing for air conditioning, heating, ventilating work. Prefers Pacific Coast. Home: Calif. $600. Se-1460.

Additional listings of positions and men available are maintained in the offices of E.S.P.S. Direct inquiries to nearest office. A weekly bulletin of engineering positions open is available at a subscription rate of $4.50 per quarter or $14 per annum, payable in advance.

Positions Available

Chicago Office

Mechanical-Hydraulic Design Engineer, 25–40, for a newly established, well-capitalized organization engaged in design and development of patented mechanical-hydraulic telemetry devices. Company seeking qualified engineers to serve as a nucleus of development group. $8,000–$12,000. Texas. C-8612.

Machine-Design Engineer, mechanical graduate, preferably to 45; to initiate and follow through on design of automated assembly equipment to replace present hand-assembly methods. Three to five years' experience in design of automatic machinery for feeding and assembly of miniature and small parts essential. Some shop experience helpful. $9500–$12,000. Company pays fee. Chicago, Ill. C-8570.

Mechanical-Systems Engineers, BS or MSME; seven to ten years' experience in as many of the following areas as possible: (*a*) Experience in the design and development of propulsion system and knowledge of various types of prime movers, including small diesel and gas-turbine engines; (*b*) design and development experience with high-speed rotary machines; (*c*) servo-system analysis experience. Duties will include applied R&D in the advanced development group on advanced engine-driven, electric-propulsion systems. These drives will be applied to several types of vehicles in the range of 100 hp and up. $9000–$12,000. Company pays fee. Southern Wis. C-8342.

Maintenance Engineer, marine equipment, graduate marine or mechanical engineer, to 40, at least four years' experience in maintenance of marine equipment to guide efforts of maintenance crew repairing heavy barges and tows. May consider applicant more or less experienced in marine equipment. $8,000–$10,000. Company will negotiate fee. Forty miles southwest of Chicago, Ill. C-8323.

New York Office

Engineers. (*a*) Production supervisor, at least five years' supervisory fabricating experience covering heavy welded machinery bases and structures. $8000–$10,000. (*b*) Welding engineer, design, production, and inspection experience covering welded structures and equipment. $7000–$9000. (*c*) Welding foreman, experience in fabricated steel plant. $7000–$9000. Substantial profit-sharing bonus. N. J. W-241.

Sales Engineer, mechanical or chemical graduate, process-equipment sales experience, to sell filters and separators to paper, food-processing, and chemical industries. Open. New England. W-237.

Engineers. (*b*) Senior project engineer, graduate mechanical, experience in design, development of machinery to create new manufacturing techniques feasible for conversion to automation. Experience in electric motors, lighting components, material handling, etc. from creation of idea and equipment through design, installation, and production. (*c*) Electromechanical engineer, graduate mechanical, minimum of three years' experience of design, drafting, and mechanical-development work. Will design, develop, and follow up to completion necessary plantwide equipment and facilities. Salaries: (*b*) $8520–$10,632. (*c*) $7044–$8124. Pa. W-228.

Engineers. (*a*) Systems engineer, 25–35, graduate mechanical or electrical, two to five years' experience in static and dynamic development, including analysis of servo systems. Most desirable background would include systems which utilize electrohydraulic servo-valves, pistons, motors, pumps, servo amplifiers and transducers. $9000–$11,000, plus profit sharing. (*b*) Methods (manufacturing) engineers, 28–40, graduate mechanical or industrial, familiar with the details of manufacturing methods for precision machined parts. Should also be familiar with tooling, fixtures, precision-machining processes and precision-gaging processes. $8000–$9000, plus profit sharing. (*c*) Prototype engineer, 25–32, graduate mechanical or electrical, minimum of two years' background in hydraulics or electronics necessary. Experience in design, instrumentation, controls. Familiarity with missile-type hardware and military specifications desirable. $8500–$11,000, plus profit sharing. Upstate N. Y. W-226.

Maintenance Engineer, graduate mechanical or electrical, to 40, experienced in maintenance and evaluation of the operation of large housing projects. Estimate heating, plumbing, electrical systems, costs, for repair and improvement. Prepare specifications and write reports. Some

travel through N. Y., N. J., and New England. $9000. Headquarters, New York, N. Y. W-219.

Project Engineer, about 35, graduate mechanical, practical and theoretical experience in the design and fabrication of steel-plate and structural members. Must be able to write specifications calling for the bending of steel plate and also welding; should be able to run preliminary stress analyses on fabricated plates and beams. Company manufactures construction equipment of various types. $9000–$12,000. Northern N. J. W-212.

Director R&D, graduate, to organize and start-up an R&D department for a large toy manufacturer. Must have broad knowledge in the plastic field, i.e., injection molding and some electromechanical experience. $12,000–$15,000. New York, N. Y. W-208.

Senior Design Engineer, mechanical graduate, at least five years' supervisory automatic and production-machinery experience including machine tools and automation of assembly line covering small motors and electromechanical products. $12,000–$15,000. Pa. W-207.

Engineers. (*b*) Tool engineer, graduate mechanical, minimum of three years' experience, to take functional specifications and translate them into design specifications. Manufacturing processes include machining, welding, and various processes. To $10,800. (*c*) Manufacturing engineer, graduate mechanical or metallurgical, to follow and trouble shoot a component or components through the manufacturing process which may include machining, welding, related processes. To $10,800. Pa. W-199.

Teaching Position for Department of Mechanical Engineering. Master's degree required; heat-transfer emphasis desired. Salary and rank dependent upon qualifications and experience. New England. W-195.

Project Engineers, graduate mechanical, 35–45, ten years' experience in the design of steam-electric generating stations for established consulting engineer. Make all calculations and specifications for equipment, controls, and installation contracts. Client contact. Ownership participation later. $10,000–$15,000. One for New York, N. Y.; one for Chicago, Ill. W-191.

Designer, graduate mechanical, seven to ten years' experience in the design of heating and ventilating systems for industrial and commercial buildings. $10,000–$11,000. New York, N. Y. W-176.

Engineers. (*a*) Chief engineer, seven years' experience in the design of die-casting tools and dies and to make sound workable designs of tooling based on good die-casting practices. Supervise subcontracting of tool and die work. Plastics experience in this field considered. $12,000–$15,000. (*b*) Tool-room supervisor to take charge of 35–40 tool and die makers. Experience in die casting or plastics field required. Administrative and scheduling work for practical and economical methods. $10,000–$12,000. Northern N. J. W-172.

Product Development Engineer, BSME or BSEE, to be responsible for development of new products through design, development, and market testing. Will supervise new product developments through liaison with engineers and through contacts with architects and contractors on job to explore need for new or improved product. Company manufactures fasteners and hardware items in metal and plastic. $10,000–$15,000. N. J. W-171.

Teaching Position in Department of Mechanical Engineering; PhD required, specialization in the fields of mechanical-engineering vibrations and stress analysis; must be interested in research in these fields. Teaching duties will be at undergraduate and graduate (MSc) level. Teaching experience desirable but not necessary. Canada. F-165.

Senior Product Development and Research Engineer, graduate mechanical, at least ten years' design, product development, and research experience on office-composing equipment. $12,000. Northern N. J. W-162.

R&D Engineer, MS preferred in mechanical engineering, strong background in design of equipment for steam-power and instrumentation fields. Capable of being assigned directly to the development of new products. Must be highly creative or inventive. $9500–$10,000, plus bonus. Eastern Pa. W-158.

Instructor for Mechanical Engineering Department, interested in and qualified in the fields of manufacturing and industrial engineering. At least MS with PhD preferred. Opportunity for a man with progressive ideas as a new manufacturing and industrial-engineering laboratory is to be built. Rank and salary dependent upon experience and ability. N. Y. State. W-145.

COMING MEETINGS

Sodium Reactor Technology

THE Atomic Energy Commission will conduct an unclassified symposium on Sodium Reactor Technology on May 24–25, 1961, at Lincoln, Neb., in cooperation with the Consumers Public Power District. All persons interested in sodium reactor technology are invited to attend.

The purpose of the symposium is to acquaint industry representatives with the status of research, development, construction, and operation of sodium cooled nuclear reactors and supporting technology.

The symposium will be held in the Pershing Municipal Auditorium, starting at 8:00 a.m., May 24, and concluding at about noon, May 25. The symposium agenda include sessions on the status of sodium cooled reactor projects, the development work and studies being conducted, and a panel discussion on present and future sodium reactor programs.

While the closing date for advanced registration is May 1, 1961, registrations will be accepted at the door. The registration fee, which includes luncheons on both days, a banquet, and a tour of the Hallam Nuclear Power Facility, is $10. Overnight accommodations will be arranged if requested.

Inquiries and advanced registrations should be sent to: Mr. Charles Sayre, Consumers Public Power District, 1401 "O" Street, Lincoln, Neb.

Solid State Mechanics

THE many recent changes in various fields of engineering have made essential a broad, up-to-date knowledge of material behavior in the design of machines, structures, and other engineering devices.

Therefore a Seminar on Solid State Mechanics has been scheduled at Penn State, which will be held June 11 to 23 at The Pennsylvania State University.

Joseph Marin, Mem. ASME, professor and head of the Department of Engineering Mechanics at Penn State, said the course is planned for research, design, and materials engineers in industrial, governmental, and educational institutions, as well as for metallurgists, physicists, and chemists engaged in various aspects of materials science.

Detailed information may be obtained from the Conference Center, The Pennsylvania State University, University Park, Pa.

Underwater Acoustics

AN INTRODUCTION to underwater acoustics at the graduate level, including sound propagation in the ocean, transducers, and methods of underwater acoustic measurements will be provided in The Pennsylvania State University's Underwater Acoustics Seminar to be held at University Park, Pa. June 18 to 23. V. M. Albers is chairman of the seminar.

A detailed brochure is available by writing to the Conference Center, The Pennsylvania State University, University Park, Pa.

Controls of Many Kinds to Be Discussed at Second JAC Conference

Automatic control has been the prime subject of two committees' discussions the past several months. The two committees, steering and program, are joint groups from five technical societies, including ASME, AICHE, AIEE, IRE, and ISA, working toward a common goal—a first-rate 1961 Joint Automatic Control Conference.

To be held June 28–30 at Boulder, Colo., the second joint conference will reflect a consensus of what's best in control, hammered out in various meetings since last September's first successful effort at M.I.T. Basis for decisions was 123 abstracts submitted to the JACC program committee by those who want to present papers.

Sessions will mix papers from various societies that fall in the same general areas. Among many others, themes include: Hydraulic and pneumatic control, process dynamics, and special topics in control. Headed by H. M. Paynter of M.I.T., the program committee has selected the most promising suggestions for session papers.

Meanwhile, the steering committee, led by R. K. Adams, ISA, is co-ordinating out-of-session activities that include a women's program and a banquet. For advance programs of the JACC meeting, write to Meetings Manager, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa. And make your registration early, room space in Boulder will be at a premium because of vacationers.

CANDIDATES FOR MEMBERSHIP AND TRANSFER IN ASME

THE application of each of the candidates listed below is to be voted on after May 25, 1961, provided no objection thereto is made before that date and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

New Applications and Promotions

Alabama

DOTY, JAMES W., Sheffield
●ELY, RICHARD E., Huntsville
WESTERVELT, FRANK H., JR., Sheffield

Arizona

HOENIG, STUART A., Tucson
McCOY, JOE, Tucson
SEAMES, ALBERT E., Tucson

Arkansas

ADAMS, HUGH L., Bassett

California

CONSTABLE, ALFRED F., Panorama City
DANEHY, RAY G., San Bruno
DHARMARAJAN, SANGIAH N., San Diego
JOHNSON, ROBERT R., Burlingame
KASCHUBE, GUNTHER A., San Francisco
NOVOBILSKI, JOHN A., Panorama City
●PROWETT, ROBERT H., La Canada
SACKMAN, JEROME L., Berkeley
SANDERS, FREDERICK A., San Francisco

Colorado

●HALL, WILLIAM O., Lakewood
●SHEDA, RAYMOND M., Denver

Connecticut

BUCK, RICHARD S., Hartford
GOFF, RANDALL, Weston
HILLMAN, OTHELLO M., Stanford
HOCHMUTH, FRANK W., Windsor
KAZAL, DAVID J., Milford
WARREN, EDWARD L., Shelton
WEAVER, VINCENT P., Waterbury

Delaware

WICKLI, HERBERT E., Newark

Florida

CROW, WILLIAM B., Gainesville
SNIDER, HAROLD F., Pompano Beach

Hawaii

HONEYCHURCH, FRANK E., Aiea
●MAHONY, JOHN W., Honolulu

Illinois

FORSYTH, DONALD W., Chicago
HINTERBERGER, HENRY, Chicago
JENNINGS, JOHN R., Downers Grove
JOHNSON, EDWARD A., Chicago
KUGLER, CALVIN N., Palos Heights
MEYERS, PERRY S., Wayne City
NEISES, JOHN T., Chicago
SKAWSKI, FLOYD J., Villa Park
SMITH, VERNON L., Western Springs

Indiana

DUCKETT, GERALD P., Indianapolis
FITZGERALD, JAMES T., East Chicago

Iowa

DEBARTHE, DAVID D., Lamoni
HUGHES, RUSSELL A., Kellerton
SWENSON, DONALD E., Ames

Kansas

ROGERS, A. C., JR., Wichita

Kentucky

MCPHERSON, JOHN L., Paducah

Louisiana

BARNWELL, JOSEPH H., Ruston
IRLAND, FRANK W., Shreveport

Maryland

CLANCY, THAMAS M., Takoma Park
●MCDANIEL, WEYMOUTH N., Baltimore
●VLCEK, JOSEPH F., Annapolis

●Promotion to Member or Affiliate

Massachusetts

BRYANT, RICHARD C., Lynn
DIX, ROBERT W., Wilmington
GREENE, ARNOLD H., Newton
HOPKINS, WALTER, Amherst
PARENT, LUCIEN A., Fairview
RICHTER, DENNY G., Wilbraham
ROUSSEAU, RAYMOND A., New Bedford

Michigan

●BRAUN, EUGENE R., Royal Oak
●FOSTER, RICHARD W., Jackson
JAIN, NAROTTAN L., East Lansing
JONES, JR., EARL C., Jackson
●MA, BENJAMIN M., Ann Arbor
MATHUR, SATYA P., Ann Arbor
●ROGO, CASIMIR, Detroit

Missouri

GUTMANN, PAUL F., JR., St. Louis

Nebraska

●PETERSON, JOHN W., Omaha

New Jersey

GUERSTER, RENE L., Millville
HAGEMAN, WALTER, Scotch Plains
HAWLEY, GEORGE F., Bogota
KRUGER, IRVING D., Haddonfield
RASHID, ABDUL, Jersey City
SCOTT, RICHARD D., Camden
●SMITH, ROBERT I., Newark

New Mexico

●BUSH, EDGAR D., JR., Los Alamos

New York

BAILEY, JOHN R., JR., Hicksville
BAISCH, CLIFFORD L., Wellsville
BENNETT, THOMAS E., New York
BOHATA, JOSEPH J., Centereach L. I.
BOLSINGER, RICHARD D., Schenectady
FINNEGAN, JAMES R., New York
●FITZROY, NANCY D., (MRS.) Schenectady
GEIER, JOHN W., Yonkers
GIBELMAN, MICHAEL A., Brooklyn
HATSELL, KEITH C., Montour Falls.
HOLTUM, RICHARD R., New York
IRWIN, ARTHUR S., Jamestown
LE FROIS, JOSEPH H., Rochester
MEHAN, RICHARD L., Scotia
NAGEL, CARL E., JR., Mamaroneck
NIXON, JAMES I., JR., Schenectady
O'TOOLE, MARTIN F., Great Neck
●PETERSEN, DALE E., Delmar
SEGEL, LEONARD, Buffalo
SELIKOFF, WILLIAM, Buffalo
●SUTTON, HENRY C., JR., Halesite, L. I.
TICE, EDWARD A., New York
TROELLER, LAURENCE C., Elmhurst
●VOSS, JOACHIM W., Forest Hills
WILEY, ROBERT F., Corning

North Carolina

BOGDON, LAWRENCE J., Winston Salem

Ohio

CHOATE, DAVID C., New Richmond
DORSETT, LEONARD S., Alliance
●FISHER, EUGENE F., JR., Vandalia
FRITZSCH, GUENTHER D., Canton
●HAUF, JOSEF, Massillon
HONIOUS, HAROLD B., Dayton
KELLY, ALBERT A., Cincinnati
●PLEBAN, EUGENE J., Cleveland
●SLAYBAUGH, RICHARD M., Toledo
SUPP, WILLIAM E., Xenia
WELTY, RICHARD C., Akron
●PETRY, WILLIAM M., Akron
TURNER, ROBERT E., Cincinnati

Oklahoma

BEEGHLY, BERT E., Bartlesville
TWILLEY, GEORGE W., Tulsa

Pennsylvania

CARLSTEDT, RAGNAR L., Latrobe
CATANACH, WALLACE M., JR., Easton
CHEVALIER, CHARLES E., University Park
●EBERHARDT, HARRY A., III, King of Prussia
HILL, ROBERT A., Philadelphia
HOOK, MICHAEL J., Erie
●HUSTON, ALFRED B., Erie
●PAKVIS, ADRIAN, Pittsburgh
RABAS, THOMAS J., Lester
●SPIEGLER, JOHN, Bradford
●THOMPSON, GORDON V., Pittsburgh
THORN, DONALD E., Bethel Park

South Carolina

ALEXANDER, DAVID C., Hartsville
GRAY, JAMES C., Greenville
WILLIAMSON, THOMAS D., Lugoff

Tennessee

LUNN, WALLACE E., Nashville
●O'CONNOR, WILLIAM M., Chattanooga
●PANNELL, MELVIN C., Knoxville
ROBINSON, ALLAN M., Memphis

Texas

BLACKWOOD, WILLIAM H., III, Orange
DRAKE, JIMMY W., Dallas
ELORRIAGA, PETER, JR., Houston
GREENE, THOMAS J., Beaumont
LEVOSKY, JOHN M., Port Neches
MARTINEZ, EUGENE P., Beaumont
LI, K. Y., San Antonio
STEWART, RANDOLPH J., Port Arthur
WILSON, FRIEND A., Beaumont
WOOD, CHARLES D., III, Garland
WRIGHT, JOSEPH F., Houston

Virginia

HELMS, THOMAS C., Lynchburg
●LEONARDY, SIDNEY P., Lackey
RENCSOK, CHARLES F., Hampton

Washington

ALLEN, JAMES D., Spokane
NATU, KASHINATH R., Spokane
PATERSON, STEWART, JR., Bellevue

West Virginia

EDDY, CHARLES E., Weirton

Wisconsin

MCFADDEN, DAVID B., Milwaukee
WILSON, JOHN F., Hales Corners

Foreign

BIRSS, RONALD J., Toronto, Ont., Canada
BROWN, WILLIAM G., Ottawa, Ont., Canada
CONNOR, JOHN A., Kent, England
DAS, MANOJ B., Mannheim, West-Germany
DE LA CRUZ, PATROCINIO F., Sampaloc, Manila, P. I.
DE LEON, CARLOS S., JR., Bulacan, P. I.
DESBAILLETS, JACQUES A., Montreal, Que., Canada
DOCKEN, GORDON C., Toronto, Ont., Canada
FELARCA, SILVERIO L., Manila, P. I.
GUPTA, KRISHNA, S., Jodhpur, India
HAINES, JOHN L., Islington, Ont., Canada
HALLAM, BRIAN J., Montreal, Que., Canada
LAHIRI, BARODA K., Nagada, India
LEE, MICHAEL B. P., Manchester, Lancs., England
MARANAN, VIRGILIO R., Makati Rizal, P. I.
NOVAK, JENO C., Kingston, Jamaica, BWI
PADLAN, PABLO L., Bulacan, P. I.
QUINONES, JUAN R., Makati Rizal, P. I.
SWIRTANSKI, JOHN S., Toronto, Ont., Canada

OBITUARIES

William E. Beggs (1889–1959), president, W. E. Beggs, Inc., Seattle, Wash., died, October, 1959. Born, Denver, Colo., Feb. 27, 1889. Parents, William A. and Nettie A. Beggs. Education, high school. Married Ruby Clarke, 1911. Mr. Beggs formed his own mechanical-contracting company several decades ago. He had formerly been a partner, from 1922 to 1933, in the University Plumbing and Heating Co., Seattle. He specialized in heating, ventilating, and power plants throughout his career, which began in 1908. He was then a journeyman steamfitter with the Seattle Heating and Plumbing Co., but soon after became foreman in charge of construction with Adams and Moffat Co. Later, after a period in Calgary, Alta., Canada, with Lonquet and King Co., engineers and contractors, he rejoined Adams and Moffat to take charge of business for a year in Victoria, B. C. From 1914 to 1921, he was an engineer with the Carnation Milk Products Co. Mem. ASME, 1929. He worked on the ASME committee interested in engineering registration. He was a member of ASHRAE and the Engineers Club of Seattle, and was a registered professional engineer in Washington State.

James Ivan Brennan (1882–19587), consulting engineer, U. S. Government, Athens, Greece, died about three years ago according to a notice

received recently by the Society. Born, Pittsburgh, Pa., Nov. 9, 1882. Parents, James Joseph and Elizabeth Seraphe (Dugal) Brennan. Education, DS, Duquense Univ., 1925; Hon. PhD, Louvain Univ., Belgium, 1928. Mr. Brennan served as a consulting engineer at various times during the course of his career, both for the U. S. Government and for the City of Pittsburgh. For several years, he also was chief engineer of the Crucible Steel Company of America, Pittsburgh, where he had charge of the design, construction, and maintenance of all properties. During World War I, he was an officer and instructor in special field schools. After his discharge in 1919, he resumed his former post with the Crucible Steel Co., but discontinued this to become managing engineer of the City of Pittsburgh. At the city's request, he supervised all of its departments for five years, declining an offer of another term in 1927 to resume his consulting practice in public works and industrial projects. This extended to several major projects abroad, leading to his work in Athens, Greece, on public projects. He authored numerous project reports and was granted several patents. He held the Order of Leopold, the War Cross, and the Order of the Crown from Belgium; the Croix de Guerre from France; and the Victory Medal and the Purple Heart from the U. S. Government. Assoc-Mem. ASME, 1911; Mem. ASME, 1917. He was a member of the Society of American Military Engineers, and a fellow of the American Association for the Advancement of Science.

Frank Shaw Clark (1882–1961), retired consulting engineer, South Pasadena, Calif., died Jan. 17, 1961. Born, New Orleans La., May 4, 1882. Parents, Walton and Alice Maud (Shaw) Clark. Education, CE, Pennsylvania Military College, 1901; BS(ME), Univ. of Pennsylvania, 1904. Married Marie Victoire de Rosset, 1907. Mr. Clark was an engineer with Stone and Webster Engineering Corp., Boston, Mass., since 1912. He became a consulting engineer there on steam power station layout and research in 1926. Some of his work in that capacity included surveying and reporting on power supplies for organizations such as the Virginia Electric and Power Co., Norfolk, Va.; the Southern California Edison Co., Long Beach, Calif.; the El Paso Electric Railway Co., El Paso, Texas; the Puget Sound Power and Light Co., Renton, Wash., and many others. He advised many of these companies on the general design features of their power stations. Mr. Clark also worked up cases and testimony for hearings before the public service commissions and for various courts in connection with lawsuits and cases involving commission hearings. These included coal-dust nuisance cases, and an arbritration case involving the Blackstone Valley Gas and Electric Co. versus the Rhode Island Power Transmission Co. A constant researcher in power production and supply, he attended the World Power Conference in Berlin in 1930, and for two months afterward traveled through Europe to study the art of power generation as it was practiced abroad. Before joining Stone and Webster, he worked with several other Ohio firms, among them The Cincinnati Traction Co., the Ft. Wayne and Wabash Valley Traction Co., and the Ohio Electric Railway Co. He authored numerous articles for the technical press. Assoc-Mem. ASME, 1909; Mem. ASME, 1912; Fellow ASME, 1938. He served on the ASME Boiler Code Committee for about 20 years. He presented a paper entitled "The Effect of Large Boilers at High Capacities on Investment and Operating Cost" at the 1929 ASME Annual Meeting. He held membership in The Franklin Institute, the Edison Electric Institute, and the Engineers Club of Boston. He was a registered professional engineer in the Commonwealth of Pennsylvania.

Edward James Collins (1928–1960), development engineer, Hood Ruber Co., Watertown, Mass., died, Jan. 15, 1960. Born, Lowell, Mass., June 4, 1928. Education, BS(ME), Lowell Technological Institute, 1954; MS, 1956. Mr. Collins worked with Hood Rubber Co. since graduating in 1956. Assoc. Mem. ASME, 1956. He is survived by his wife.

Robert Craig (1876–1960), consulting engineer and patent attorney, Maplewood, N. J., died, March, 1960. Born, Galt, Ontario, Canada, May 24, 1876. Parents, William and Jessie E. (Sommerville) Craig. Education, ME, Univ. of Minnesota, 1897. Naturalized U. S. Citizen, Minneapolis, Minn., 1902. Married Carrie Swift, 1903; children, William S., Robert S., and Richard A. Craig. A specialist in scales, weighing machinery, and gas engines, Mr. Craig designed and developed a line of scales, pitless automobile turntables, adjustable screw presses, and portable floor cranes. He gained his early knowledge in the field during college vacations, working on gas engines and weighing scales. After graduating, he spent a few years working on gas and steam engines with several companies, and then went to Europe in the summer of 1900 to study gas and oil engines in factories and at the Paris Exposition. Returning to the States, he went to work with Fairbanks, Morse and Co., St. Paul, Minn., for three years, and then went with A. F. Chase and Co., Minneapolis, selling and servicing Maxwell and Olds automobiles. Later, he moved to Los Angeles, Calif., where he had his own shop, doing oxy-acetylene welding, general machine work, and manufacturing. It was at this time that he designed his own line of special machinery, which soon went on the market. In 1918, he came east again to develop automatic scale inventions for the Computing Scale Co. of America. From 1924 to 1925, he was a consulting engineer specializing in patent causes in Dayton, Ohio; and in 1926, became a patent attorney in New York, where he was associated with Cooper, Keer and Dunham. Assoc-Mem. ASME, 1918; Mem. ASME, 1924. He was a member of Sigma Xi, National Scale Men's Association, The Franklin Institute, SAE, and the Dayton Engineers Club.

Max Eldon De Armond (1936–1960), trainee, Allis-Chalmers Mfg. Co., Milwaukee, Wis., died, Milwaukee, Sept. 21, 1960. Born, Joplin, Mo., Feb. 24, 1936. Education, attended Kansas State Teachers College; ME, Georgia Institute of Technology, 1957. Assoc. Mem. ASME, 1957.

Le Roy Adolph Droescher (1900–1960), vice-president, C. H. Wheeler Mfg. Co., Philadelphia, Pa., died, Oct. 5, 1960. Born, Baltimore, Md., Feb. 15, 1900. Parents, Arthur John and Lena Caroline Droescher. Education, attended Baltimore Polytechnic Institute and Lehigh Univ. Married Julia E. Suwall, 1923; children, Kathleen R. and Julia C. Droescher. Mr. Droescher joined C. H. Wheeler Co. in 1923 as a test engineer on the development of steam-jet airejectors and heat-transfer equipment. In 1929, he became manager and chief engineer of the marine and industrial and process-vacuum equipment department, becoming vice-president upon the death of Mr. Wheeler. Mr. Droescher co-authored the section on steam-jet airejectors for volume two of "Marine Engineering," a textbook. He held a patent on a vacuum-cooling apparatus. The U. S. Navy Bureau of Ships awarded him its certificate of commendation in 1947. Mem. ASME, 1946. He worked on the ASME Test Code for Cooling Towers. He was a member of The Franklin Institute, The Society of Naval Architects and Marine Engineers, the Society of Naval Engineers, and the American Oil Chemists Society; and worked on the Heat Exchange Institute Technical and Research Committee. He was a registered professional engineer in the State of Pennsylvania.

Henry Beveridge Duffus (1897–1960), accident-prevention administrator, Industrial Relations Div., Westinghouse Electric Corp., Pittsburgh, Pa., died, Nov. 23, 1960. Born, Perth, Scotland, Sept. 29, 1897. Education, graduate, Bliss Electrical School, Washington, D. C., 1923; attended Northeastern Univ. Since his graduation from the electrical school in 1923, Mr. Duffus worked with Westinghouse in various capacities, also making special contributions in the field of industrial safety. Beginning as an engineering tester, he advanced to assistant foreman of test operations for automotive electrical equipment, and in 1927 was appointed supervisor of inspection and tests in a new plant for manufacturing commercial radio equipment. At the same time, he became safety engineer for the plant, continuing in this capacity throughout his later position as supervisor of production and engineering tests of the company's Small Motor Division. He became safety engineer for the East Springfield operation in 1936, and in 1941 took over this service for the entire corporation. He was appointed manager of the accident-prevention service in 1947, the administrator of accident prevention, co-ordinating corporation policies, in 1953. He served as a consultant to safety engineers and plant management at 92 plants and shops. For the last two decades, he wrote about two articles a year for trade and safety publications. He was a former editor of Newsletter, National Safety Council Section. Mem. ASME, 1955. He presented a paper on "Mechanical Lanes of Safety" at the ASME 1940 Annual Meeting in New York; and one on "Standards for Safer Material Handling Slings Developed Through Coordinated Engineering" at the 1954 Semi-Annual Meeting in Pittsburgh. He was a member and second vice-president of the American Society of Safety Engineers; chairman of the Safety Standards Board and of Z16 and B11 Standards Committees of the American Standards Association; member of the Industrial Conference of the National Safety Council; and a past vice-president and board-of-directors member of the Western Pennsylvania Safety Council. From 1936 to 1941, he was a special agent for the U. S. Department of Labor for the conservation of manpower in U. S. industry.

Everett Owen Eastwood (1876–1960), professor-emeritus of mechanical engineering, Univ. of Washington, Seattle, Wash., died, Dec. 15, 1960. Born, Portsmouth, Va., Feb. 5, 1876. Parents, Matthew D. and Mary Anne (Thornton) Eastwood. Education, CE, Univ. of Virginia, 1896; BS, 1897; AB and AM, 1899. BS, Massachusetts Institute of Technology, 1902. Married Nelle Dorothy Halliwell, 1905; children, Emily Louise Eastwood Bunker, and Mary Elizabeth Eastwood Ashford. Professor Eastwood was a member of the University of Washington faculty since 1905, when he joined it as assistant professor of mechanical engineering. Advancing through associate professor to professor, he became head of the mechanical engineering department. He also was consulting engineer for the university, as well as its director of aeronautical engineering, 1930–1946, and its director of civil-aeronautical training. During World War I, he was in charge of special training courses for marine engineers, U. S. Shipping Board, and naval ensigns, Naval Recruiting Service, at the university. Professor Eastwood also conducted a private practice and was prominent in various business enterprises. Before going to the University of Washington, he was an instructor in mechanical engineering and naval architecture at Lehigh University, Bethlehem, Pa. He had also previously been connected with the science department of the Bureau of Construction and Repairs, Washington, D. C., and the Fore River Shipbuilding Co., Quincy, Mass. From 1896 to 1900, he was a fellow in astronomy at the University of Virginia. He was an Associate editor on the magazines *Heating, Piping and Air Conditioning*, *Combustion Engineering*, and *Engineering and Finance*. Mem. ASME, 1914; Fellow ASME, 1936. He was vice-president of ASME, 1911–1913, and President, 1924–1925. He was elected a manager of ASME in 1923. In 1919 and 1920, he served as a delegate from the ASME Washington Section, and as a member of the ASME Nominating Committee. He was a charter member of that section, was on its executive committee, and served as its secretary-treasurer. He was ASME representative on the American Engineering Council. He was a former vice-president and chairman of the board of directors of the University National Bank, Seattle, Wash. He held membership in Sigma XI, Tau Beta Pi, and ASHRAE.

Joseph H. Fisher (1916–1960), supervisor of engineering, Mutual Chrome Division, Solvay Process Division, Allied Chemical Corp., Baltimore, Md., died, Nov. 18, 1960. Born, Baltimore, Dec. 2, 1916. Education, graduate, Baltimore Polytechnic Institute, 1945; Johns Hopkins Univ. Mr. Fisher worked as a design engineer with various chemical companies throughout his career. Beginning with Davison Chemical Co., Curtis Bay, Md., in 1939, he later went with Revere Copper and Brass Co., and then with the Chemical Pigment Co., a division of Glidden Co., as a mechanical-design engineer in the manufacture of paint pigments. In 1951, he became a plant engineer with the National Gypsum Co., Baltimore, manufacturer of wall board and plaster. Before going with Allied Chemical, he was a design engineer with the Mutual Chemical Co., Assoc. Mem. ASME, 1953. Surviving is his wife, Betty.

Charles von Hoffmann Foulds (1894–1960), consulting engineer, Portland, Ore., died, July 23, 1960. Born, Berkeley, Calif., June 30, 1894. Parents, John Evans and Mary Augusta (Frick) Foulds. Education, BS, Univ. of California, 1916. Married Adarhyle Verne Cambers, 1917; children, Barbara Verne and John Charles. Mr. Foulds was a specialist in power-plant and heavy-machinery application, design, and manufacture. His profession took him to many parts of the world. From 1916 to 1932, he was an engineer with a Pelton Water Wheel Co., San Francisco, Calif. After a period doing general design work for the company, he was sent to Norway to take charge of installing seven 4500-hp water-wheel units for an aluminum plant. He went to India in 1920 to take charge of similar but larger installations, and also spent some time in British Columbia before returning home in 1925 to become executive engineer in charge of the company's engineering activities. He directed research work to improve the efficiency of impulse-type water wheels that led to the development of general laws by which highly efficient units were constructed. He became manager in 1929. He left this work in 1932 to take a position with the Public Works Administration as an examining engineer, and then went with Placer Management, Ltd., as a consulting hydraulic engineer. In this post, he directed the design and purchase of hydroelectric plants for New Guinea and Colombia, S. A. For a number of years, he also worked as a consulting engineer with Empresa de Energía Eléctrica, Medellín, Colombia. He held numerous patents on hydraulic equipment and air-blast circuit breakers. Assoc-Mem. ASME, 1919; Mem. ASME, 1930. He was a member of the Engineer's Club in San Francisco, and a licensed civil engineer in the State of California.

Dudley Kimball French (1881–1960?), retired consulting engineer, died recently according to a notice received by the Society. Born, Chicago, Ill., May 1, 1881. Parents, Harry Dudley and Ellen Mable (Kimball) French. Education, attended Univ. of Chicago. Married Helen M. Nind, 1910; children, Margaret and Katherine. Mr. French was a consultant in power development and industrial-water treatment since 1932. He had previously been associated with the Dearborn Chemical Co., as a chemical director, and with the Commercial Testing and Engineering Co., Chicago, Ill., as a chemical engineer. He contributed several articles to technical publications, and held a patent for a cleaning and protective oil. Mem. ASME, 1928. He worked

on the ASME Boiler Code, and was a member of the ASME Boiler Feedwater Studies Research Committee. He was a member of the American Chemical Society, ASTM, The American Water Works Association, and the American Institute of Consulting Engineers.

Wilhelm Gumz (1901–1961), mechanical engineer, Steinkohlen-bergbauverein, Essen, Germany, died, Jan. 22, 1961. Born, Rombach/Lorraine, France, May 21, 1901. Education, ME, Karlsruhe and Darmstadt, 1924; PhD, Berlin Engineering Univ. Dr. Gumz materially influenced developments in furnace construction in the last 20 years through his scientific work in fuel technology and gasification of solid fuels. Early in his career, he participated in the development of the high-pressure Benson boiler at the Siemens-Schuckert works in Berlin. Later he was chief engineer and then general manager of the Air Preheater Co., Berlin, and then went with the Heidelberg Power Co. In 1939, he joined the coal industry in research on coal utilization with the Steinkohlenbergbauverein in Essen, the research center of the Ruhr coal-mining industry. He also was editor of *Feuerungstechnik*, a technical magazine devoted to fuel-utilization problems, from 1936 to 1944. Coming to the U. S. A. in 1947, he did research on coal gasification and carbonization at the Trenton, N. J., laboratories of Hydrocarbon Research, Inc., New York, until 1949. After spending a period as a consultant at Battelle MemorialI nstitute, Columbus, Ohio, he then returned to the Steinkohlenbergbauverein. He authored a dozen books and more than 100 papers on problems of pulverized coal firing, gasification, combustion, corrosion, slag formation, air heating, heating-value calculation, and competition between oil and coal. Among his books is "Gas Producers and Blast Furnaces," published in New York in 1950. He was credited with a number of patents. Mem. ASME, 1950. He was an active participant in sessions of the ASME Fuel Division during his years in the U. S. A. He was a member of Verein Deutscher Ingenieure (VDI).

Walter Matthew Hausel, (1892–1961), mechanical engineer, Breesport, N. Y., died, Jan. 24, 1961. Born, Astoria, L. I., N. Y., August 26, 1892. Education, graduate, Pratt Institute, 1914. Mr. Hausel worked to improve plant economy through industrial studies of time, methods, and labor costs. With the Chevrolet Motor Co., Tarrytown, N. Y., from 1918 to 1922, he was production and equipment engineer, eventually taking charge of production control and cost reduction. He helped to standardize workmanship and reduce costs as a supervisor at Western Electric Co., New York City, from 1923 to 1927, and then joined Ford, Beacon and Davis Inc., New York, where he made industrial surveys for plant and manufacturing improvements. Assoc.-Mem. ASME, 1918; Mem. ASME, 1930.

Ragnar Axel Hummel (1886–1959), president and general manager, Lone Star Cement Corp., New York, N. Y., died, August, 1959. Born, Torsjo, Sweden, Sept. 11, 1886. Education, ME, Chalmer Univ., Gothenburg, Sweden, 1907. Naturalized U. S. citizen, Illinois, 1919. Mr. Hummel was associated with Lone Star Cement Corp. for several decades. A worker in steel foundries during his early carreer in this country, he became a designer and assistant works manager with The American Steel Foundries, Granite City, Ill., on sand-handling and automatic molding machiner. He spent a period in 1913 and 1914 as a designer with the Chicago Harbor and Subway Commission, and then went with the LaSalle Portland Cement Co., LaSalle, Ill., where he was later placed in charge of the engineering department and field work. He designed and supervised the erection of mill buildings and steel structures. In 1918, after a period with the Bates and Rogers Construction Co. of Chicago, he went to Argentina to take charge of a cement plant for the International Cement Corp., and later became superintendent of a plant in Cayo Mason, Cuba, and vice-president and manager of a plant in Brazil. Then he returned to New York to be vice-president of engineering and management for the corporation. He was director of the Argentine Portland Cement Co., the Uruguay Portland Cement Co., the American and Foreign Power Co., Inc., and Carey-Baxter-Kennedy. He was vice-chairman of the U. S. International Council and director of the Pan-American Society of the U. S. Mem. ASME, 1922.

Dickson Edward Krebs (1934–1961), planning officer, U. S. Navy, San Francisco, Calif., died, Jan. 24, 1961. Born, Orange, N. J., May 21, 1934. Education, attended Rensselaer Polytechnic Institute; ME, Univ. of Missouri, 1957. Assoc. Mem. ASME, 1957.

Kenneth Lockett (1880–1961), maintenance engineer, Department of Public Works and Buildings, Division of Highways, State of Illinois, died, Dixon, Ill., Jan. 20, 1961. Born, Chicago, Ill., Oct. 24, 1880. Education, BS(ME), Massachusetts Institute of Technology, 1902. Mr. Lockett was an engineer with the Illinois State Highway Department for about 12 years. He also had spent part of his career working on railroads and special machinery, including conveyer systems, fire protection systems, and power-plant equipment. Among the companies for whom he worked, were the Chicago Car Wheel and Foundry Co.; Adams and Schwab, consulting engineers of Chicago; the Electrical Installation Co. of Chicago; and the Acme Match Co., Roanoke, Va. He became vice-president of the Orr and Lockett Hardware Co. in 1910, dealing in general hardware. Jun. ASME, 1904; Assoc-Mem. ASME, 1907; Mem. ASME, 1913. Surviving is a brother, Harold, of Aldie, Va.

Thomas E. Major (1910–1960), chief engineer, McNeil Machine and Engineering Co., Akron, Ohio, died, Oct. 8, 1960. Born, Peninsula, Ohio. Jan. 20, 1910. Education, ME, Univ. of Akron 1932. Mr. Major joined the Summit Mold and Machine Co., which later became the McNeil Machine and Engineering Co., in 1937. He started as chief draftsman and engineer in charge of the design of tire and tube vulcanized equipment. In 1943, he was an assistant chief engineer in development, field engineering, and rubber curing machinery, later becoming chief engineer for the company. He held an earlier position from 1928 to 1937 with the Goodyear Tire and Rubber Co., Akron. Mem. ASME, 1952. He was a registered PE in the State of Ohio.

J. John McGee (1889–1960), retired mechanical engineer, Quebec, Canada, died, Dec. 25, 1960. Born, Montreal, Canada, April 21, 1889. Parents, Patrick J. and Mary (Coyle) McGee. Education, high school. Married Margaret Carmody, 1923; children, Rita, John, James, Francis, Gerald, and Robert. Mr. McGee was a draftsman with the Canadian Pacific Railway Co., Montreal, Canada, from 1925 to 1954, when he retired. He specialized in machine and tool design. From 1913 to 1925, he held a number of positions as a designing draftsman with other Canadian companies, among them the Montreal Light, Heat and Power Co., Ltd.; Canadian Vickers Co., Ltd.; and the Harbour Commission of Montreal. Assoc-Mem. ASME, 1924; Mem. ASME, 1935.

James Smith Merritt, Jr. (1896–1961?), manufacturer's representative, Philadelphia, Pa., died recently according to a notice received by the Society. Born, Abington, Pa., May 31, 1896. Education, attended Univ. of Pennsylvania. Mr. Merritt served as a manufacturer's representative in the sale of coal and ash-handling equipment since 1919. For a number of companies, including the Brooke Engineering Co., Inc.; United Conveyer Corp.; and The Fairfield Engineering Co., he surveyed existing facilities and made preliminary designs in preparation for installing this equipment. Mem. ASME, 1956.

Thomas Robert Hoysted Murphy (1884–1961), retired industrial consulting engineer, formerly with The Mead Corp., Dayton, Ohio, died, Jan. 24, 1961. Born, New Brighton, Cheshire, England, Sept. 16, 1884. Parents, John Michael and Anne Caroline (Hoysted) Murphy. Education, BS, Rutgers Univ. Naturalized U. S. citizen, Brooklyn, N. Y. Married Margaret Brooks, 1910; children, Margaret Marie, Patricia Brooks, Thomas Stephen, and Catherine Aylmer. Married 2nd, Marie Counsellor, 1948. Mr. Murphy was a specialist in the management of pulp and paper manufacturing properties. He was consulted on the design and construction of many paper mills, including newsprint and paperboard mills, in Canada and the U. S. A. As an operating engineer, 1906–1914, with Joseph H. Wallace and Co., Ltd., consulting engineers in New York City, he helped to introduce the sodium-sulfate process in the U. S. A. while a resident engineer with the Roanoke Rapids Mfg. Co., Roanoke Rapids, N. C. The Roanoke mill was the first mill in this country to demonstrate commercially the use of Southern Pine wood for sodium-sulfate (kraft) pulp and paper, and the first mill in North America to use the diffusion system of washing pulp. It was the forerunner of the vast kraft pulp, paper, and paperboard industry of the southern U. S. Mr. Murphy became vice-president of Joseph H. Wallace and Co., Ltd., in 1914. By 1916, he was again actively consulting on pulp mill design. After a period with the Engineering and Development Co., Dayton, Ohio, he joined the Mead Investment Co., an affiliate of The Mead Corp., with offices in Dayton; New York City; and Toronto, Montreal, Canada. He held a series of positions with the company until his retirement. During that part of his career, he was consulted on paper mills that were designed and built in North Carolina, Tennessee, Virginia, Florida, and various parts of Canada. Jun. ASME, 1911; Assoc-Mem. ASME, 1916; Mem. ASME, 1935. He was a member of the Engineering Institute of Canada and the Technical Association of the Pulp and Paper Industry (TAPPI), and was a registered professional engineer in the states of New York and Connecticut. He is survived by his wife, Marie; his son, and three daughters; stepmother, Mrs. Ada Murphy, Washington, D. C.; six sisters, Mrs. Julia Richards, Miss Elizabeth Hoysted, and Miss Winifred Mury, all of New York, Mrs Christopher Smiles, Wilton, Conn., Mrs. Harry Crooks, Baltimore Md., and Mrs. Dorothy Hall, Washington, D. C.; a brother, Bernard Murphy, New York City; nine grandchildren, and four great-grandchildren.

James Morgner Reynolds (1924–1960), field service engineer, Automatic Transmission Div., Ford Motor Co., Livonia, Mich., died, April 26, 1960. Born, Detroit, Mich., March 15, 1924. Education, BS(ME), Michigan State College, 1948. Before joining the Ford Motor Co., Mr. Reynolds was a motor-equipment engineer with the Michigan Bell Telephone Co., Detroit. Assoc-Mem. ASME, 1948. Surviving is his wife, Mary Lee, Birmingham, Mich.

John M. Riordan (1884–1961), president Riordan Machinery Co., Detroit, Mich., died Jan. 23, 1961. Born, Brighton, Mass., Jan. 8, 1884. Education, Armour Institute course and correspondence. Mr. Riordan began his career in 1901 doing machine shop work on the construction of complete automobiles. He worked first with the Crest Mfg. Co. and then with the Peerless Motor Car Co., for whom he later took charge of the service department. With the Fellows Gear Shaper Co., Springfield, Vt., from 1912 to 1915, he traveled through the middle western United States taking up problems of gear and gear-case design on installations of many types of machinery from cream separators to elevators and coal mining equipment. In the following years he worked with the Grant Lees Co., Cleveland, Ohio, and then became general manager of The Cleveland Planer Co., and later of The Vahan Products Co., manufacturer of automobile motor parts. Mem. ASME, 1921.

William Burton Sanders (1893–1961), professor of mechanical engineering, Purdue Univ., died, Jan. 10, 1961. Born, Wellington, Ill., Dec. 2, 1893. Parents, Robert Hayes and Minnie Amelia (Ferry) Sanders. Education, BS(ME), Purdue Univ., 1919; MSME, 1922. Married Emma Christina Nehrig, 1915; children, William Burton and Elizabeth Louise. Professor Burton began teaching at Purdue University in 1918. At that time he had a background as a teacher in the Mecca (Indiana) public schools, and as an engineer in power plants with the Indiana Railway and Light Co., Kokomo, Ind., and the Studebaker Corp. He was an instructor in physics at Purdue until 1920, when he began teaching applied mechanics there. In 1925, he became an assistant professor of applied mechanics and chemical engineering, rose to associate professor in 1931, and to a professorship in engineering mechanics in 1944. He was coordinator of research projects in engineering mechanics at Purdue since 1945. A registered PE in Indiana, he also was a consulting engineer. Mem. ASME, 1947. He was a member of the American Society for Engineering Education, Tau Beta Pi, and Theta Tau.

William Andrew Schmid (1902–1960), vice-president, City Product Corp., Chicago, Ill., died, November, 1960. Born, Cincinnati, Ohio, Sept. 6, 1902. Education, ME, Univ. of Cincinnati, 1926. A specialist in refrigeration, Mr. Schmid began working as a draftsman with the City Ice and Fuel Co., Cincinnati, in 1923, but soon became an assistant engineer on the design of refrigeration plants in St. Louis for the company. He returned to Cincinnati in 1927 to work with the Ball Ice Machine Co., a subsidiary of City. Starting as an erection engineer, he rose through the ranks to become vice-president of the company in 1943. As vice-president, he was in charge of engineering for a year, then moved to New York to take charge of eastern operations, but went back to Chicago in 1946 to be in charge of national retail-commercial operations. He made technical contributions to MECHANICAL ENGINEERING and to *Power* magazine. Assoc.-Mem. ASME, 1926. Mem. ASME, 1946.

Harry Edwin Stevens (1934–1961?), graduate student, Rensselaer Polytechnic Institute, Troy, N. Y., died recently according to a notice received by the Society. Born, Albany, N. Y., Sept. 29, 1934. Education, BME, Union College, 1956; attended Wayne State Univ., Detroit, Mich. Mr. Stevens was briefly with E. I. du Pont de Nemours & Co., Inc., Niagara Falls, N. Y., before joining the U. S. Air Force in 1957. Assoc. Mem. ASME, 1960.

Robert Elgie Sykes (1907–1960), director of research, Electric Sprayit Co., Sheboygan, Wis., died, Nov. 21, 1960. Born, Bowling Green, Ohio, July 23, 1907. Education, extension courses, Battle Creek College and Notre Dame Univ. Mr. Sykes was a designer of air compressors and pumps, working in that field throughout his career with a number of companies. Before joining the Sprayit Co., he was chief engineer in charge of production, sales, and research engineering department with The De Vilbiss Co., Toledo, Ohio. He began his career in Battle Creek, Mich., with the Union Steam Pump Co., as a pump designer and mechanical engineer, and between then and 1950 held a series of positions as chief and mechanical engineer with companies in Indiana, Illinois, and New York. Among these were the Dodge Mfg. Corp., Mishawaka, Ind.; the Fairbanks Morse and Co., Chicago, Ill.; the Yeomans Bros. Co., Chicago and the Rumsey Pump Co. Ltd., Seneca Falls, N. Y. From 1939 to 1940, he developed a line of centrifugal pumping equipment as president of Sykes Pumps, Inc., Chicago. He held a patent for an electrical control system. Mem. ASME 1943. Surviving is his wife, Ruth.

DESIGN ENGINEERING '61

ASME CONFERENCE AND SHOW

COBO HALL • DETROIT, MICH. • MAY 22-25, 1961

SHOW: Floor Plans • List of Exhibitors • How to Get to Cobo Hall

ASME CONFERENCE: Program in Brief • Digest of Papers • Order Form

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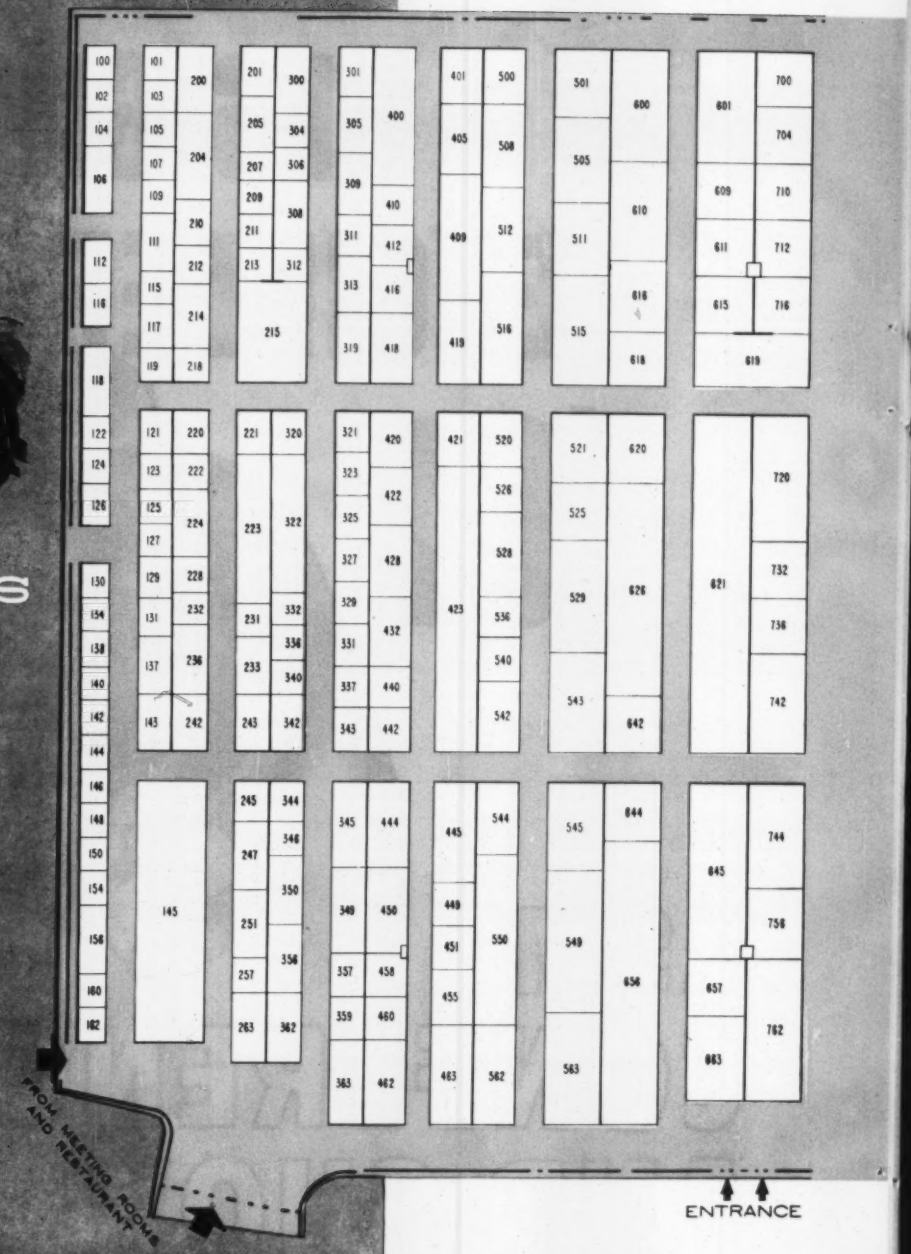
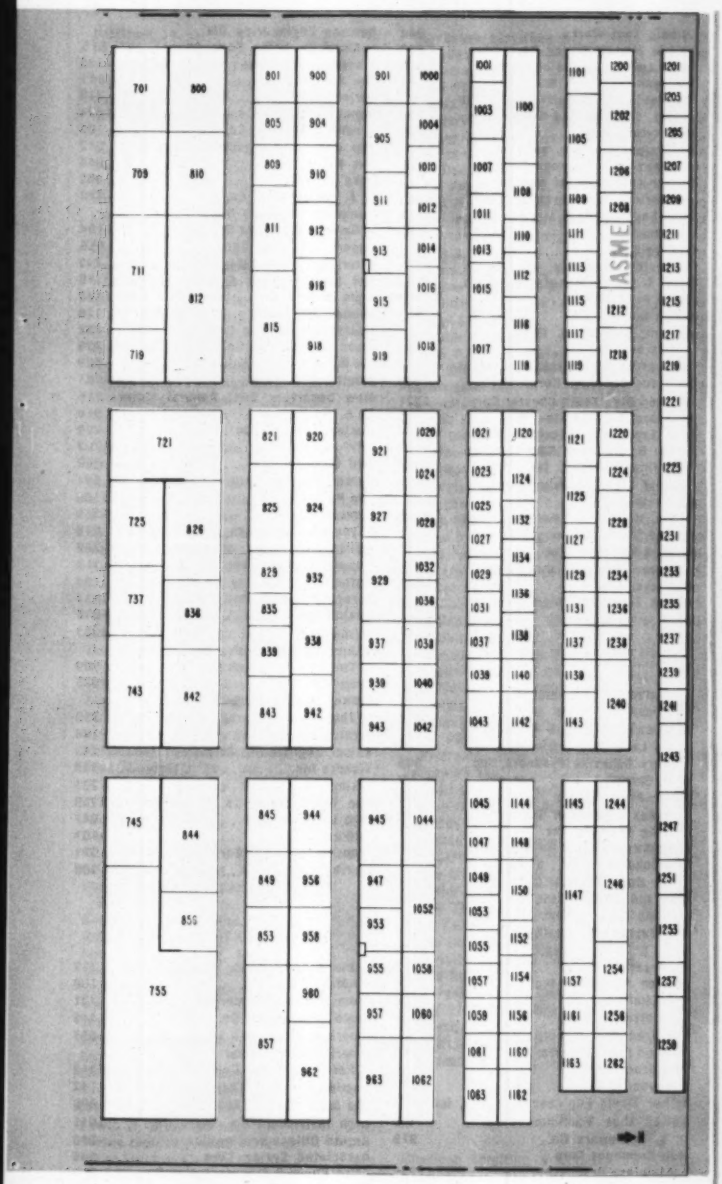
Admittance to the 1961 Design Engineering Show is by registration only. There is a registration fee of $2.00, payable only at the registration desk in Cobo Hall.



COBO HALL-DETROIT, MICH.

ELECTRICAL AND ELECTRONIC COMPONENTS

	Booth No.
ACF Electronics Div., ACF Industries, Inc.	1023
The Adams & Westlake Co.	201
The Louis Allis Co.	945
Aluminum Co. of America	721
Anaconda Metal Hose Div., The American Brass Co.	312
The Anderson Company, Roton Products Div.	800
The Auburn Manufacturing Co.	540
Automatic Switch Co.	825
Bendix Computer Div., The Bendix Corp.	1147
The Bristol Co.	1036
Brook Motor Corp.	1121



list of EXHIBITORS

	Booth No.
The Brush Beryllium Co.	657
Buchanan Electrical Products Corp.	720
Burling Instrument Company, Inc.	124
Carr Fastener Co., Div., United-Carr Fastener Corp.	1242
Carter Controls, Inc.	1005
Century Electric Co.	921
Cherry Electrical Products Corp.	1118
Circle F Mfg. Co.	422
Cleveland Graphite Bronze Div of Clevite Corp.	121
Cleveland Machine Controls Corp.	336
Columbus Electric Manufacturing Co.	1055
Coors Porcelain Co.	1262
Crane Packing Co.	237
Deluxe Coils, Inc.	1116
Detroit Controls Div. of American Radiator & Standard	
E. I. du Pont de Nemours & Co., Sanitary Corp.	257
Dixon Sintaloy Inc.	1059
The Dobeckmun Co. A Div. of The Dow Chemical Co.	745
Film Department	860
Durakool, Inc.	442
Eagle Signal Corp.	1014
Eaton Manufacturing Co.	656
Ebert Electronics Corp.	1119
Eclipse Mach. Div., The Bendix Corp.	1147
Electric Boat Div. and Electro Dynamic Div. of General Dynamics Corp.	709
Electro-Flex Heat, Inc.	112
Electro-Mechanical Instrument Co.	1148
ETC Inc.	1157
Fawick Airflex Div., Fawick Corp.	224
Fenwal Inc.	450
Flexible Controls Corp.	1140
Franklin Electric Co., Inc.	1052
Garlock Inc.	618
General Controls Co.	1024
General Electric Co.	423
Gleason Reel Corp.	1015
Gries Reproducer Corp.	1143
Haydon Div. of General Time Corp.	853
Heinemann Electric Co.	1247
Heyman Manufacturing Co.	218
Illinois Tool Works	844
Janette Div. of National Pneumatic Co., Inc.	101
Landis & Gyr, Inc.	1160
Lead Industries Assoc.	111
Licon Division, Illinois Tool Works	844
Linemaster Switch Corp.	1145
Martin Engineering Co.	138
Metals & Controls Inc., a Corporate Division of Texas Instruments Inc.	1201
Miller Electric Co.	300
Minneapolis-Honeywell Regulator Co.	1211
Mueller Brass Co.	701
Mycalex Corp. of America	1063
National Beryllia Corp.	1134
National Tube Div., U. S. Steel	632
New Departure Div., General Motors	118
Panduit Corp.	1217
Permacel	212
P. I. C. Design Corp., Subs. of Benrus Watch Co.	340
The Polymer Corp.	1105
Potter & Brumfield, Div of American Machine & Foundry Co.	1162
Ramsey Corp.	1215
Randall Graphite Bearings, Inc.	1016
Reynolds Metals Co.	215
M. H. Rhodes, Inc.	162
Riehle Testing Machines Div. American Machine & Metals, Inc.	857
Robbins & Myers, Inc.	356
Robertshaw-Fulton Controls Co., Acro Div.	223
Bridgeport Thermostat Div.	223
Fulton Syphon Div.	223
Scully-Jones and Co.	205
Sigma Instruments, Inc.	211
Simplatrol Products Corp.	1161
Stahlin Bros. Fibre Works, Inc.	1061
Sterling Precision Corp.	1001
Edwin B. Stimpson Co., Inc.	1100
Stokes Molded Products Div. of The Electric Storage Battery Co.	319
Sylvania Electric Products Inc.	542
Syntron Co.	743
The Thomas & Betts Co., Inc.	228
United Shoe Machinery Corp.	400
U. S. Electrical Motors Inc.	508
Veeder-Root Inc.	243
Warner Electric Brake & Clutch Co.	1246
Web Controls Corp.	247
Westinghouse Electric Corp.	356
Westline Products Div. of Western Lithograph Co.	142
Edwin L. Wiegand Co.	220
Zenith Electric Co.	1237

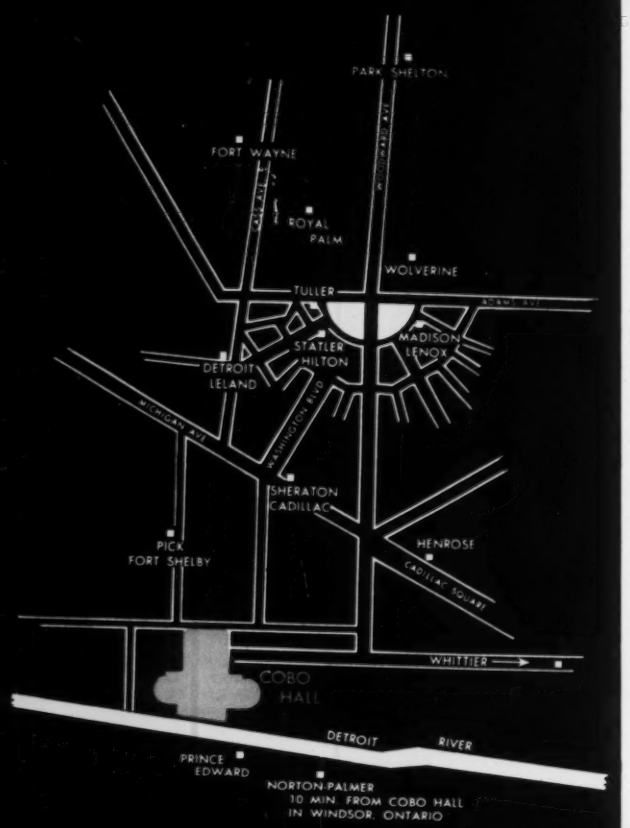
ENGINEERING EQUIPMENT AND SERVICES, PUBLICATIONS, AND MISCELLANEOUS

	Booth No.
Aircraft & Missiles	349
American Optical Co.	1139
ASME	1210
Automotive Industries	349
Battelle Memorial Institute	238
W. H. Brady Co.	321
Canada, Dept. of Trade & Commerce	145
Chart-Pak Inc.	458
Chilton Co.	349
Cobehn, Inc.	102
Design News	758
Electro-Technology	320
Encyclopaedia Britannica, Inc.	1207
FAC Div., Overseas Commodex Corp.	
Fairchild Publications, Inc.	1109
Florida Development Commission	1150
The General Fireproofing Co.	942
General Motors Corp., Research Lab.	704
Hamilton Manufacturing Co.	620
Hitchcock Publishing Co.	1137
Hydraulics & Pneumatics	1253
Industrial Equipment News	1239
The Industrial Press	1209
The Industrial Publishing Corp.	1253
The Iron Age	349
Lead Industries Assoc.	111
Lisle Corp.	1224
Machine Design	363
Mariane Development Co., Inc.	306
Materials in Design Engineering	963
Mayline Company, Inc.	732
Metalworking News	1109
Minnesota Mining and Manufacturing Co., Micro-Film Products	550
Moeller Manufacturing Co., Inc.	1257
New Hermes Engraving Machine Corp.	130
Ozalid, A Div. of General Aniline & Film Corp.	200
Pack Manufacturing Co.	1238
Plan Hold Corp.	1131
Power Transmission Design	1253
Precision Metal Molding	1253
Product Design & Development	710
Product Engineering	263
Prudential Industries, Inc.	505
Rotherm Engineering Co., Inc.	104
Selectrons, Ltd.	306
Space/Aeronautics	320
Stacor Equipment Co.	418
Edwin B. Stimpson Co., Inc.	1100
Sweet's Catalog Service, Div. of F. W. Dodge Corp.	663
Technical Services Div., Rogers Publishing Co.	1009
Thomas Publishing Co.	1239
Unitech Corp.	1127
United Shoe Machinery Corp.	400
Universal Drafting Machine Corp.	432
Web Controls Corp.	247
Welding Design & Fabrication	1253

FASTENERS AND ADHESIVES

	Booth No.
Acme Steel Co.	301
Aluminum Co. of America	721
American Screw Co.	835
American Sealants Co.	131
The Auburn Manufacturing Co.	540
Avery Label Co., A Div. of Avery Adhesive Products, Inc.	905
W. H. Brady Co.	321
The Bristol Co.	1036
Carr Fastener Co., Div., United-Carr Fastener Corp.	1242
Chicago Rivet and Machine Co.	1218
Corbin Cabinet Lock Div., The American Hardware Corp.	1223
Corbin Hose Clamp Div., The American Hardware Corp.	1227
Dzus Fastener Co., Inc.	428
Eastman Chemical Products, Inc. Chemicals Div.	719
Eaton Manufacturing Co.	656
Elastic Stop Nut Corp. of America	720
Elizabeth Div., Elastic Stop Nut Corp. of America	720
Fasson Products, A Div. of Avery Adhesive Products, Inc.	416
Ferry Cap & Set Screw Co.	809
H. B. Fuller Co.	1129
B. F. Goodrich Aviation Products, A Div. of B. F. Goodrich Co.	420
Gries Reproducer Corp.	1143
Groov-Pin Corp.	1221
John Hassall, Inc.	927
Heli-Coil Corp.	1043

How to Get to COBO HALL



	Booth No.
Illinois Tool Works	844
Kaynar Manufacturing Co.	1010
The Lamson & Sessions Co.	140
MacLean-Fogg Lock Nut Co.	242
Minnesota Mining & Mfg. Co., Adhesive, Coatings and Sealers Div.	550
The Nylok Corp.	440
The Palnut Co., Div. of United-Carr Fastener Corp.	115
Parker-Kalon Div. of General American Transportation Corp.	451
Penn Engineering & Mfg. Corp.	1213
Permacel	212
Ramsey Corp.	1215
Raybestos-Manhattan, Inc.	918
Reed & Prince Manufacturing Co.	1220
Robin Products Co.	103
Rosan Inc.	337
Russell, Burdsall & Ward Bolt and Nut Co.	937
Shakeproof Div., Illinois Tool Works	844
Simmons Fastener Corp.	957
Southco Div., South Chester Corp.	1021
Standard Pressed Steel Co.	815
Star Expansion Industries Corp.	331
Edwin B. Stimpson Company, Inc.	1100
Tinnerman Products, Inc.	345
Tubular Rivet and Stud Co.	350
The Ucinite Co., Div. United-Carr Fastener Corp.	1240
United Shoe Machinery Corp.	400
Waldes Kohinoor, Inc. Truarc Retaining Rings Div.	1018
Weckesser Co.	100
Wittek Manufacturing Co.	526

FINISHES AND COATINGS

	Booth No.
Aluminum Co. of America	721
American Nickeloid Co.	1042
American Smelting & Refining Co.	711
Avery Label Co., A Div. of Avery Adhesive Products, Inc.	905
W. H. Brady	321
Chemo Products, Inc.	332
Clad-Rex Division of Simoniz Co.	309
Coating Products Inc.	938
Columbus Coated Fabrics Corp.	525
The Dobeckmun Co., A Div. of The Dow Chemical Co.	745
Lead Industries Assoc.	111
Marlane Development Co., Inc.	306
The Masland Duraleather Co.	944
Metal & Thermit Corp.	1049
Permacel	212
Poloron Products, Inc.	716
Poly Chem, Inc.	1138
The Polymer Corp.	1105
Rigidized Metals Corp.	1045
Roehlen Engraving Works	536
Selectrons, Ltd.	306
Shwayder Bros. Inc.	1057
Arthur Tickle Engineering Works, Inc.	323
United Shoe Machinery Corp.	400
U. S. Stoneware Co.	919
Wall Colmonoy Corp., Stainless Processing Div.	1234

HYDRAULIC AND PNEUMATIC COMPONENTS

	Booth No.
AFCO Fitting Co., Div. of The United States Air Compressor Co.	953
Aeroquip Corp.	619
Airmatic Valve, Inc.	1152
Air-Maze Corp.	160
Aluminum Co. of America	721
Anaconda Metal Hose Div. The American Brass Co.	312
The Anderson Co., Roton Products Div.	800
The Auburn Manufacturing Co.	540
Automatic Switch Co.	825
Chemiquip Co.	1200
Chicago-Allis Manufacturing Corp.	154
Cleveland Graphite Bronze Div. of Clevite Corp.	121
Clippard Instrument Laboratory, Inc.	1013
Combination Pump Valve Co.	805
Commercial Filters Corp.	214
Crane Packing Co.	237
Crawford Fitting Co.	1108
The D. S. D. Manufacturing Co.	222
De Laval Steam Turbine Co.	836
Denison Engineering Div., American Brake Shoe Co.	615
Disogrin Industries	1235
The Flodar Corp.	311
Garlock Inc.	618
General Controls Co.	1024
Greene, Tweed & Co.	105
The Hansen Manufacturing Co.	512
The Heim Co.	843
Hoke Inc.	455
E. F. Houghton & Co.	920
Humphrey Products Div., General Gas Light Co.	1154
Imperial-Eastman Corp.	956
International Packings Corp.	742
The Joyce-Cridland Co.	1110
Kobe Inc.	123
Leiman Bros., Inc.	129
Martin Engineering Co.	138
Mead Specialties Co.	839
Mo-Bar Hydraulic Sales Co.	829
Mueller Brass Co.	701
New Departure Div., General Motors	118
C. A. Norgren Co.	910
Nuclear Products Co.	209
OPW-Jordan Corp.	1202
Pall Corp.	960
Parker-Hannifin Corp.	544
The Polymer Corp.	1105
Ramsey Corp.	1215
Raybestos-Manhattan, Inc.	918
Roller Bearing Co. of America	362
Roper Hydraulics, Inc.	119
Rotherm Engineering Co., Inc.	104
Screen Products, Inc.	1117
Sealol Inc.	1058
Sigmamotor Inc.	1233
Skinner Electric Valve Div., The Skinner Chuck Co.	900
Snap-Tite, Inc.	1029
Stokes Molded Products Div. of The Electric Storage Battery Co.	319
Stratoflex Inc.	106
Valcor Engineering Corp.	1243
Vickers Inc.	549
Viking Pump Co.	1231
The Weatherhead Co.	1259
Web Controls Corp.	247
Wilkerson Corp.	107
Wooster Division, Borg-Warner Corp.	501
Worthington Corp.	308

MECHANICAL COMPONENTS

	Booth No.
Aetna Ball and Roller Bearing Co.	213
Air-Maze Corp.	160
Aluminum Co. of America	721
Amco Engineering Co.	449
American Machine & Metals, Inc.	857
American Stock Gear Div., Perfection Gear Co.	1212
Amplex Division, Chrysler Corp.	1142
The Anderson Co., Roton Products Div.	800
Arch Instrument Co., Inc.	1011
Arguto Oilless Bearing Co.	210
Associated Spring Corp.	445
Atlas Chain & Manufacturing Co.	505
The Auburn Manufacturing Co.	540
B-Mold Div., Buckeye Brass & Mfg.	1032
Barry Controls Inc.	904
Beaver Precision Products, Inc.	410
Binks Manufacturing Co.	519
Boston Gear Works	342
Carr Fastener Co., Div., United-Carr Fastener Corp.	1242
Chain Belt Co.	929
Chicago-Allis Manufacturing Corp.	154
Cleveland Graphite Bronze Div. of Clevite Corp.	121
Commercial Filters Corp.	214
Controlex Corp. of America	122
Corbin Cabinet Lock Div., The American Hardware Corp.	1223
Corbin Hose Clamp Div., The American Hardware Corp.	1227
Crane Packing Co.	237
Dayton Industrial Products Co., Division of Dayco Corp.	1017
Disogrin Industries	1235
Dixon Sintaloy Inc.	1059
Duff-Norton Co.	401
Dynamic Gear Co., Inc.	134
Dzus Fastener Co., Inc.	428
Eaton Manufacturing Co.	656
Eriez Manufacturing Co.	245

list of EXHIBITORS

	Booth No.
Falstrom Co.	821
Faultless Caster Corp.	1038
Fawick Airflex Div., Fawick Corp.	224
Flexible Controls Corp.	1140
Garlock Inc.	618
General Bearing Co.	1132
General Electric Co.	423
Gleason Reel Corp.	1015
Gleason Works	500
Gries Reproducer Corp.	1143
Hart Reduction Pulley Co.	109
Hartford Steel Ball Co.	1205
The Hartwell Corp.	915
The Heim Co.	843
Heyman Manufacturing Co.	218
Hoover Ball and Bearing Co.	1062
Hunter Spring Co., Div. of American Machine & Metals, Inc.	857
Illinois Tool Works	844
Industrial Tectonics, Inc.	1000
Instrument Specialties Co., Inc.	343
International Packings Corp.	742
The Kaydon Engineering Corp.	137
Kennametal Inc.	562
Landis & Gyr, Inc.	1160
Lignum-Vitae Products Corp.	144
Link-Belt Co.	743
Lord Manufacturing Co.	912
Manheim Mfg. & Belting Co.	1241
McGill Manufacturing Co., Inc.	1031
Metal Powder Industries Federation	826
Moeller Manufacturing Co., Inc.	1257
Mono-Race Div., The Thew Shovel Co.	412
Mueller Brass Co.	701
National Tube Div., U. S. Steel	632
New Departure Div., General Motors	118
Nice Ball Bearing Co.	1060
The Ohio Gear Co.	1136
Ohio Seamless Tube Div. of Copperweld Steel Co.	811
Orange Roller Bearing Co., Inc.	1020
Owatonna Tool Co.	1203
Paktron Div., Illinois Tool Works	844
Paramount Textile Machinery Co.	1254
Park Nameplate Co., Inc.	947
P. I. C. Design Corp., Subsidiary of Benrus Watch Co.	340
The Polymer Corp.	1105
Ramsey Corp.	1215
Randall Graphite Bearings, Inc.	1016
Raybestos-Manhattan, Inc.	918
Robert Shaw-Fulton Control Company Fulton Sylphon Div.	223
Robbins & Meyers, Inc.	356
Roller Bearing Co. of America	362
Rollway Bearing Co., Inc.	117
Sandusky Foundry & Machine Co.	405
Screen Products, Inc.	1117
Scully-Jones and Co.	205
Sealol Inc.	1058
Sier-Bath Gear & Pump Co.	958
Sigmamotor Inc.	1233
Simmons Fastener Corp.	957
Spiroid Division, Illinois Tool Works	844
Sterling Precision Corp.	1001
Edwin B. Stimpson Co., Inc.	1100
Stokes Molded Products Div. of The Electric Storage Battery Co.	319
Stow Manufacturing Co.	150
Syntron Co.	743
Tann Corp., Congress Drives Division	924
Thomson Industries, Inc.	962
United Shoe Machinery Corp.	400
U. S. Electrical Motors Inc.	508
U. S. Gauge Div., American Machine & Metals, Inc.	857
Vanton Pump & Equipment Corp., Div. of Cooper Alloy Corp.	127
Veeder-Root Inc.	243
Warner Automotive Div., Borg-Warner Corp.	501
Web Controls Corp.	247
Westplex Corp.	1156
The S. S. White Dental Mfg. Co.	916

METALS

	Booth No.
Acme Steel Co.	301
Alloy Casting Institute	329
Aluminum Co. of America	721
American Nickeloid Co.	1042
American Smelting & Refining Co.	711
American Zinc Institute	712
Armco Steel Corp.	409
Bendix Foundries, The Bendix Corp.	1147
The Beryllium Corp.	520
The Brush Beryllium Co.	657
Clad-Rex Division of Simoniz Co.	309
Cleveland Graphite Bronze Div. of Clevite Corp.	121
Climax Molybdenum Co., A Division of American Metal Climax Co.	511
Copper & Brass Research Assoc.	528
Curtiss-Wright Corp., Marquette Div.	1219
The Decatur Casting Co.	955
Drop Forging Assoc.	204
Eaton Manufacturing Co.	656
Gray Iron Founders' Society, Inc.	305
Hamilton Foundry Inc.	744
Handy & Harman	516
Haynes Stellite Co., Div. of Union Carbide Corp.	621
The International Nickel Co., Inc.	529
Janney Cylinder Co.	1163
Johnson Bronze Co.	1012
Jones & Laughlin Steel Corp., Stainless and Strip Div.	737
Kennametal Inc.	562
Laminated Shim Co., Inc.	116
LaSalle Steel Co.	563
Lead Industries Assoc.	111
Magnesium Products of Milwaukee, Inc.	1015
The Malayan Tin Bureau	1047
Malleable Castings Council	700
Maysteel Products, Inc.	1015
McLouth Steel Corp.	810
Metal Powder Industries Federation	826
Mott Metallurgical Corp.	1115
Mueller Brass Co.	701
National-Standard Co.	801
New Departure Div., General Motors	118
The Ohio Knife Co.	231
Ohio Seamless Tube Div. of Copperweld Steel Co.	811
Olin Mathieson Chemical Corp., Metals Div.	601
Poloron Products, Inc.	716
H. K. Porter Co., Inc., Riverside—Alloy Metal Div.	609
Presswork Inc.	1208
Randall Graphite Bearings, Inc.	1016
Revere Copper and Brass Inc.	521
Reynolds Metals Co.	215
Rigidized Metals Corp.	1045
Sandusky Foundry & Machine Co.	405
Space Missile Materials Corp.	1256
Superior Tube Co.	849
Arthur Tickle Engineering Works, Inc.	323
Union Carbide Corp.	621
Union Carbide Metals Co. Division of Union Carbide Corp.	621
United States Steel	632
Universal Castings Corp.	325
Washington Steel Corp.	856
Waukesha Foundry Co.	616
Wolverine Tube, Div. of Calumet & Hecla, Inc.	1111

NON-METALLIC MATERIALS

	Booth No.
American Smelting & Refining Co.	711
The Auburn Manufacturing Co.	540
Automotive Rubber Co.	932
Avery Label Co., A Div. of Avery Adhesive Products, Inc.	905
Avi Sun Corp.	419
W. H. Brady Co.	321
Cadillac Plastic Co.	207
Celanese Plastic Co., A Div. of Celanese Corp. of America	645
Chicago-Allis Manufacturing Corp.	154
Colonial Rubber Co.	919
Columbus Coated Fabrics Corp.	525
Conneaut Rubber & Plastics Co.	919
Continental-Diamond Fibre Corp.	156
Coors Porcelain Co.	1262
Crane Packing Co.	237
Disogrin Industries	1235
Dixon Corp.	146
The Dobeckmun Co., A Div. of The Dow Chemical Co.	745
Dow Corning Corp.	644
E. I. du Pont de Nemours & Co. Elastomers Chemicals Dept.	761
Film Dept.	860
Organic Chemicals Dept.	755
Polychemicals Dept.	763
Duriron Co., Inc.	1236
Eastman Chemical Products, Inc., Plastics Div.	812
Enfab, Inc.	232
Enjay Chemical Co., A Div. of Humble Oil & Refining Co.	600
Fiberfil Inc.	1101
Garlock Inc.	618
Glass Laboratories, Inc.	148
Hexcel Products Inc.	1053
Hungerford Plastics Corp.	610
Lancaster Glass Corp.	304
Lead Industries Assoc.	111
Lignum-Vitae Products Corp.	144
Marbon Chemical Div., Borg-Warner Corp.	725
The Masland Duraleather Co.	944
Minnesota Mining & Manufacturing Co., "Scotchply" Reinforced Plastics Chemical Division	550
Mycalex Corp. of America	1063
National Beryllia Corp.	1134
National Carbon Co., Div. of Union Carbide Corp.	621
National Lead Co.	545
National Vulcanized Fibre Co.	421
Nylon Molded Products Corp.	125
Ohio Rubber Co.	610
O'Sullivan Rubber Corp.	359
Pennsylvania Fluorocarbon Co., Inc.	357
Permacel	212
Polygon Plastic Co.	1251
The Polymer Corp.	1105
Raybestos-Manhattan, Inc.	918
Rohm & Haas Co.	463
Scott Paper Co. Industrial Marketing Div.	1112
Spaulding Fibre Co., Inc.	939
Stokes Molded Products Div. of The Electric Storage Battery Co.	319
Synthane Corp.	143
Toyad Corp.	344
Union Carbide Chemicals Co., Textile Fibers Div. of Union Carbide Corp.	621
Union Carbide Corp.	621
Union Carbide Plastics Co., Div. of Union Carbide Corp.	621
United States Plywood Corp.	126
United States Rubber Co. Mechanical Goods Div.	762
United States Steel	632
U. S. Stoneware Co.	919
Westchester Plastics, Inc.	1028
Westline Products Div. of Western Lithograph Co.	142

POWER TRANSMISSION EQUIPMENT

	Booth No.
Acme Chain Corp.	1004
Aluminum Co. of America	721
AMP Inc.	932
Anaconda Metal Hose Div., The American Brass Co.	312
Anderson Co., Roton Products Div.	800
Arguto Oilless Bearing Co.	210
Beaver Precision Products, Inc.	410
Boston Gear Works	342
Browning Manufacturing Co.	251
Chain Belt Co.	929
Chicago-Allis Manufacturing Corp.	154
Cleveland Graphite Bronze Div. of Clevite Corp.	121
Congress Drives Div., Tann Corp.	924
Controlex Corp. of America	122
Cullman Wheel Co.	1144
Cycledynamics, Inc.	1206
Dayton Industrial Products Co., Div. of Dayco Corp.	1017
De Laval Steam Turbine Co.	836
Diamond Chain Co., Inc.	1228
Dodge Manufacturing Corp.	322
Duff-Norton Co.	401
Eaton Manufacturing Co.	656
Eclipse Machine Div., Bendix Corp.	1147
Fawick Airflex Div., Fawick Corp.	224
Foote Bros. Gear and Machine Corp.	444
Formsprag Co.	736
General Electric Co.	423
The Heim Co.	843
The Hilliard Corp.	1120
Janette Div. of National Pneumatic Co., Inc.	101
The Kaydon Engineering Corp.	137
Link-Belt Co.	743
Lovejoy Flexible Coupling Co.	1044
Maurey Manufacturing Corp.	346
McGill Manufacturing Co., Inc.	1031
Morse Chain Co., A Borg-Warner Industry	842
National Tube Div., U. S. Steel	632
New Departure Div., General Motors Corp.	118
Randall Graphite Bearings, Inc.	1016
Raybestos-Manhattan, Inc.	918
Rollway Bearing Co., Inc.	117
Saginaw Steering Gear Div., General Motors Corp.	845
Scully-Jones and Co.	205
Sealol Inc.	1058
Sier-Bath Gear & Pump Co., Inc.	958
Sigmamotor Inc.	1233
Simplatrol Products Corp.	1161
The Snow Nabstedt Gear Corp.	1039
Sterling Precision Corp.	1001
Stow Manufacturing Co.	150
Tann Corp., Congress Drives Div.	924
Thomas Flexible Coupling Co.	943
Tormag Products Div. of Gleason Reel Corp.	1015
United Shoe Machinery Corp.	400
U. S. Electrical Motors Inc.	508
United States Rubber Co., Mechanical Goods Div.	762
Waldron-Hartig Div., Midland-Ross Corp.	327
Warner Electric Brake & Clutch Co.	1246
Web Controls Corp.	247
Winsmith Inc.	1244
T. B. Wood's Sons Co.	901
Worthington Corp.	308

SHAPES AND FORMS

	Booth No.
Alloy Products Corp.	221
Aluminum Co. of America	721
Aluminum Extrusions, Inc.	313
American Machine & Metals, Inc.	857
American Smelting & Refining Co.	711
The Auburn Manufacturing Co.	540
B-Mold Division, Buckeye Brass & Mfg. Co.	1032
Casting Engineers Div., Consolidated Foundries & Mfg. Co.	460
Chemo Products, Inc.	332
Chicago-Allis Manufacturing Corp.	154
Colonial Rubber Co.	919
Conneaut Rubber & Plastics Co.	919
Continental-Diamond Fibre Corp.	156
The Decatur Casting Co.	955
Disogrin Industries	1235
Dixon Sintaloy Inc.	1059
Drop Forging Assoc.	204
Falstrom Co.	821
Garlock, Inc.	618
Glass Laboratories, Inc.	148
Gray Iron Founders' Society, Inc.	305
Gries Reproducer Corp.	1143
H P L Jersey Co.	911
H P L Manufacturing Co.	911
Hamilton Foundry Inc.	744
Haynes Stellite Co., Div. of Union Carbide Corp.	621
Hitchiner Manufacturing Co., Inc.	1025
Hunter Spring Co., A Div. of American Machine & Metals, Inc.	857
Janney Cylinder Co.	1163
Laminated Shim Co. Inc.	116
Lignum-Vitae Products Corp.	144
Melray Manufacturing Co.	911
Metal Powder Industries Federation	826
Mueller Brass Co.	701
National Beryllia Corp.	1134
National Tube Div., U. S. Steel	632
Ohio Seamless Tube Div. of Copperweld Steel Co.	811
O'Sullivan Rubber Corp.	359
Owens-Corning Fiberglas Corp.	462
Pennsylvania Fluorocarbon Co., Inc.	357
The Polymer Corp.	1105
Raybestos-Manhattan, Inc.	918
Roehlen Engraving Works	536
Space Missile Materials Corp.	1256
Stokes Molded Products, Div. of The Electric Storage Battery Co.	319
Superior Tube Co.	849
Toyad Corp.	344
Union Carbide Corp.	621
U. S. Gauge Div., American Machine & Metals, Inc.	857
United States Rubber Co., Mechanical Goods Div.	762

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PROGRAM IN BRIEF

MONDAY MORNING, MAY 22

Designing for Today's Competitive Market

TUESDAY MORNING, MAY 23

Manufacturing — Key to Saving
Automatic Equipment — Speeds Production
Glass and Ceramics — Offer New Design Possibilities
High-Strength Steel — Impact of Recent Development

WEDNESDAY MORNING, MAY 24

Motors — Economics and Applications
Production — Cost-Saving Hints
Adhesives — For Metal Bonding
Cost Analysis — Fasteners and Powder Parts

THURSDAY MORNING, MAY 25

Plastics — Unusual Behavior
Dynamics — Damping and Gears
Lubrication — Molydisulfides as an Answer

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DIGEST

MONDAY, MAY 22

Designing for Today's Competitive Market — 10:00 a.m.

Panel

How a Car Is Planned and Engineered With Marketing, Purchasing, Manufacturing, and Quality-Control Considerations, by *Will Scott*, executive director of Central Product Planning Office, Ford Motor Car Co., Dearborn, Mich.
Designing for Function and Cost Objectives, by *Herbert M. Bevans*, executive engineer—Chassis, Electrical, Truck Section, Engineering Div., Chrysler Corp., Detroit, Mich.
Production Engineering as It Affects Car Design and Sales, by *Conrad F. Orloff*, assistant chief engineer, Production Engineering Department, Chevrolet Motors Div., General Motors Corp., Detroit, Mich.
Role of the Supplier in Meeting Competition, by *Carl E. Burke*, chief development engineer, American Motors Corp., Detroit, Mich.

TUESDAY, MAY 23

Manufacturing — Key to Saving — 9:30 a.m.

Producibility—Designing for Production .. 61—MD-1 . . . By C. E. Warner and R. L. Berg, General Electric Company, Schenectady, N. Y. This paper appears in condensed form in May, 1961, MECHANICAL ENGINEERING.

Materials Standardization to Reduce Costs .. 61—MD-2 . . . By Gerald L. Swartwood, The Bryant Electric Company, Bridgeport, Conn.

The raw-material standardization program employed at the author's company is described. The program is directed mainly toward raw material used for punch-press parts, such as strip and coil stock, metals, and fibers.

As a result of the program, 1569 raw-material items were reduced to 708 at that company over a three and one-half year period.

Savings were found in four main categories—price reduction, order processing, inventory carrying charges, and scrap allowance. Included are complete savings formulas.

Automatic Equipment — Speeds Production — 9:30 a.m.

Special Requirements of Hydraulic Circuits for Servo Controlled Machinery .. 61 — MD-3 . . . By Robert K. Sedgwick, Kearney and Trecker Corp., Milwaukee, Wis.

Machines designed for numerical control or for mechanical-analog control derive their accuracy from the control hardware. Thus, each element in the train of command must match the capabilities of every other element.

It is generally recognized that the hydraulic method of machine operation offers the best possibilities. Hydraulic motors can deliver a wide range of power input, accelerate at fantastic rates, and

OF CONFERENCE PAPERS

make a stiff link between control and machine load.

The author explains why a comparison of constant-displacement pumps and pressure-compensated variable-displacement pumps seems to favor the latter. He also discusses size of ports and passages, details of hydraulic-motor application, amount of oil under compression, and filtration.

Which Drive — Electric, Mechanical or Hydraulic? . . 61—MD-4 . . . By George W. Younkin, Giddings and Lewis Machine Tool Company, Fond du Lac, Wis. This paper appears in condensed form in May, 1961, MECHANICAL ENGINEERING.

Glass and Ceramics — Offer New Design Possibilities — 9:30 a.m.

Ceramic Materials: A Chemical and Structural Description . . 61 — MD-5 . . . By Marvin G. Britton, Corning Glass Works, Corning, N. Y.

Ceramic materials are either glassy, or crystalline, or a combination of both. Thus a great variety of useful properties can be achieved. These include transparency, translucency, dielectric strength, low thermal expansion, and, in the completely crystalline alumina, exceptionally high strength.

By controlling the porosity of the glasses, a wide range of properties can be obtained and the elastic modulus of porous aluminum oxide can be made to range from 12.5 to 43 million psi. By combining metals and glasses, such as nickel aluminide, materials having unique combinations of properties are achieved; for example, aluminides with a bend strength of 100,000 psi at 1000 C.

The author describes various ceramic materials and concludes that in the future, design engineers will be able to develop designs exploiting the unusual properties of these materials.

Glass and Ceramics in Machine Design . . 61 — MD-6 . . . By John R. Blizard, Mem. ASME, Corning Glass Works, Corning, N. Y. This paper appears in condensed form in May, 1961, MECHANICAL ENGINEERING.

High-Strength Steel — Impact of Recent Development — 9:30 a.m.

High-Strength Steels—Part I, Materials . . 61—MD-7 . . . By R. A. Lula, Assoc. Mem. ASME, Allegheny Ludlum Steel Company, Pittsburgh, Pa.

High-Strength Steels—Part II, Design and Fabrication . . 61—MD-8 . . . By Richard H. Marvin, Mem. ASME, The Budd Company, Philadelphia, Pa.

High-strength materials are those with a high unaxial tensile strength to density ratio.

The development of high-strength steels is reviewed in these two pages, and the metallurgical and mechanical aspects of these materials are discussed. By some specific examples, it is shown how high-strength cold reduced stainless steels and precipitation hardenable steels are being used. Several examples of structures designed and fabricated in those materials are discussed. The examples cover structures that are designed principally for compressive loading or primarily for tensile loading.

WEDNESDAY, MAY 24

Motors — Economics and Applications — 9:30 a.m.

Electric Motors at Higher Temperatures for Industrial Usage . . 61 — MD-9 . . . By Frank C. Rushing, Mem. ASME, Westinghouse Electric Corporation, Buffalo, N. Y.

The principal function of the electric motor is to produce rotating torque. It converts electrical energy into mechanical energy with some loss going into heat. Heat produces temperature rise, which affects motor-insulation life. Limited insulation life is a critical factor in motor design and application. For many years there were economic and technical limitations to major usage of motors with insulation temperatures above Class A (105 C hot spot) levels. Now, there is a rapidly expanding scope of available higher temperature materials. Higher temperature motors are increasing in usage, stimulated by economies realizable through weight and size reductions. It is well under way and will eventually displace the old Class A standards.

Mechanical Application of Non-Excited Synchronous Motors . . 61 — MD-10 . . . By J. P. Landis, Mechanical Development Laboratory, E. I. du Pont de Nemours and Company, Inc., Wilmington, Del.

The polyphase induction motor has long been the work-horse for machine drives. Its extreme simplicity, ruggedness, low cost, compactness, and ease of control have earned it this position. Until recently, synchronous motors have been deficient in enough of these features to preclude their wide use. During the past five or six years, however, notable progress has been made by the electrical industry in the field of non-excited synchronous motors to overcome these deficiencies.

The behavior of this motor as a part of a mechanical system is described. The motor is presented from the mechanical engineer's viewpoint with a minimum of electrical technology.

Production — Cost-Saving Hints — 9:30 a.m.

Design Considerations and Drafting Techniques for Production on Numerically Controlled Production Machines . . 61 — MD-11 . . . By Alexander Taleff, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

Numerically controlled machines require special part design to give the greatest saving. At the same time, close tolerances and finishes add cost even though automatic machines can do the job. Charts permit optimum selection of all factors to reduce product cost.

Cost and Value of Small Tolerances and Smooth Finishes . . 61—MD-12 . . . By William W. Gilbert, Mem. ASME, General Electric Company, Schenectady, N. Y.

There is often disagreement between the designer who wants to specify small tolerances and smooth finishes to insure performance of a product, and the production man, who wants wide tolerances and rough finishes. But there are many exceptions to the rule that reduced tolerances and smoother finishes will improve the product.

The cost of manufacturing may be increased 16 times by changing from rough machining with a tolerance of ± 0.015 in. to a tolerance of ± 0.0025 in.

The data given include the relative costs of materials, processes, surface finishes, tolerances, and cutting conditions.

Adhesives — For Metal Bonding — 9:30 a.m.

Elastomeric Adhesives — Industry's New Tool . . 61 — MD-13 . . . By W. C. O'Leary, Minnesota Mining and Manufacturing Company, St. Paul, Minn.

The author discusses adhesives that are basically elastomeric in character, including a variety of products obtainable from natural, reclaimed and synthetic rubbers in combination with natural and synthetic resins, and with a variety of solvents and diluents. For the most part, this excludes the glues derived from fish, animal and blood sources, and resorcinol, phenolic, and urea glues, which provide essentially rigid bonds, and the glue-pastes derived from flour, starch, dextrines, and related materials.

Adhesives for the Bonding of Metals . . 61—MD-14 . . . By H. R. Butzlaff and K. F. Charter, A. O. Smith Corporation, Milwaukee, Wis. This paper appears in condensed form in May, 1961, MECHANICAL ENGINEERING.

DIGEST OF CONFERENCE PAPERS

Which Fastener Should We Choose . . 61—MD-15 . . . By J. W. Stoutenburg, Robin Products Company, Warren, Mich.; and Kenneth D. Ringland, Central Screw Company, Keene, N. H.

The authors evaluate the engineering and production problems pertaining to the application, function, design, and cost analysis of the fastener. Both standard and custom engineered fasteners are discussed.

Designing With Powder Metallurgy to Improve Quality and Reduce Cost . . 61—MD-16 . . . By Paul J. Failla, Johnson Bronze Company, New Castle, Pa.

Design engineers, when considering the use of powder metallurgy parts, should have a practical understanding of the fundamental limitations of this process and some of the basic design rules. Friction of powders on die wall and punch is considerable. Hence, parts compressed from the top only will be less dense at the bottom, whereas parts compressed from both top and bottom will be less dense in the middle. Pressing action is applied most conveniently and economically from top and bottom and not from sides. This imposes definite limitations on the shape of the parts that can be pressed.

The author gives six rules that the designer of a part must follow to insure proper design and to take advantage of all the things that can be accomplished by powder metallurgy. He also gives 20 examples of designs that illustrate the potential and the right and wrong in the design of powder pressings.

Filament-Wound Pressure Vessels . . 61—MD-17 . . . By Richard Gorcey, Rocketdyne, a division of North American Aviation, Inc., Canoga Park, Calif.

The full value and potential of filament winding have been recognized by a significant number of persons only within the past year. Filament winding is a process consisting of winding a reinforcing material and a resinous binder around a mandrel to form a part. The end product can exhibit vastly different properties, depending on the basic material properties of the components, the ways in which they are combined and handled, the winding equipment used, the type of mandrel employed, and the design of the part, all of which are included here in a discussion of filament winding in fabrication of pressure vessels.

The greatest potential of filament winding is perhaps in the field of pressure vessel fabrication. It is believed that eventually the majority of all pressure vessels fabricated will be filament wound, particularly where weight is critical.

An Introduction to Designing with Plastics . . 61—MD-18 . . . By R. L. Thorkildsen, Mem. ASME, General Electric Company, Schenectady, N. Y., and John V. Schmitz, General Electric Company, Louisville, Ky.

The authors introduce some unusual types of behavior encountered in plastics and the methods required for evaluating them.

The paper is divided into three parts:

1 Some common uses of plastics, their unique properties, and methods for evaluating a material in terms of its potential application.

2 The value of engineering teamwork in applying plastic materials.

3 Specific serious gaps in plastics technology, and some future needs.

It is concluded that there is a need for basic materials behavior studies that will reveal the behavior of a material under use conditions.

Visco-Elastic Damping . . 61—MD-19 . . . By D. Kent Hatch and C. Howard Adams, Monsanto Chemical Company, Springfield, Mass.

The authors present new engineering solutions to areas of continuing engineering problems in manufacturing products where vibration, shock, and misalignment are met. The ideas discussed will be of interest to engineers in the heavy equipment and automotive fields.

Effect of Misalignment on Tooth Action of Bevel and Hypoid Gears . . 61—MD-20 . . . By M. L. Baxter, Jr., Gleason Works, Rochester, N. Y.

Tooth-contact analysis, as developed by the author at the Gleason Works, is explained. This analysis permits the calculation of tooth-bearing characteristics for bevel or hypoid gear pairs in any specified running position.

Pairs of gears that will operate perfectly are developed by generating pinions with a variety of combinations of mismatch to determine the one best suited for the job.

By choosing the kind and amount of modification or mismatch for a particular application, results far superior to those from theoretically perfect conjugate teeth are obtained.

Molybdenum Disulfide as a Lubricant . . 61—MD-21 . . . By Kenneth B. Wood, Jr., Climax Molybdenum Company, a division of American Metal Climax, Inc., New York, New York.

To meet the increasingly rigid performance requirements on modern materials, engineers are relying more and more upon lubricants. Among the advances in this field is the growing use of molybdenum disulfide (MoS_2) in boundary lubrication as contrasted with hydrodynamic lubrication.

Research data is presented on MoS_2 as a lubricant, including basic properties, typical analyses of commercially available grades, relationships between basic properties and lubrication theory, principal formulations of MoS_2, laboratory evaluations of its performance, and some major applications.

Molybdenum Disulfide as an Additive to Automotive Greases . . 61 — MD-22 . . . By H. G. Rudolph, Jr., Socony Mobil Oil Company, Inc., New York, N. Y.

Molydisulfide as an additive to general purpose conventional lubricants is relatively new. Molybdenum disulfide is especially attractive as a grease additive because it is almost completely inactive, is chemically stable, and does not oxidize in air until the temperature exceeds 750 F. If air is excluded, molybdenum disulfide is thermally stable above 2000 F.

It was not until 1956 that a supply of molybdenum disulfide of suitable particle size and free of abrasives became available in quantity. But results have been more than encouraging as compared with those obtained from a good lithium-base multipurpose automotive grease.

YARWAY news briefs

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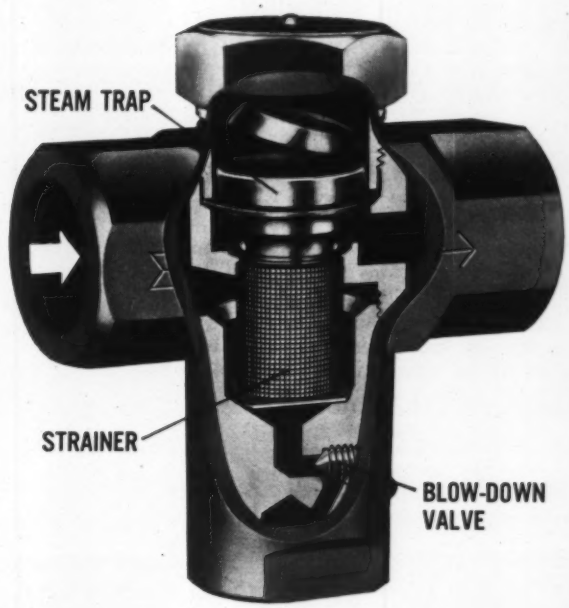
So it goes—industry's welcome to the new Yarway Series 130 combination steam trap has been a warm one. Already manufacturing quotas have been doubled to meet the demand. Yarway distributors everywhere are busy answering their customers' requests for demonstrations.

What will the new Series 130 do for you? Consider these advantages:



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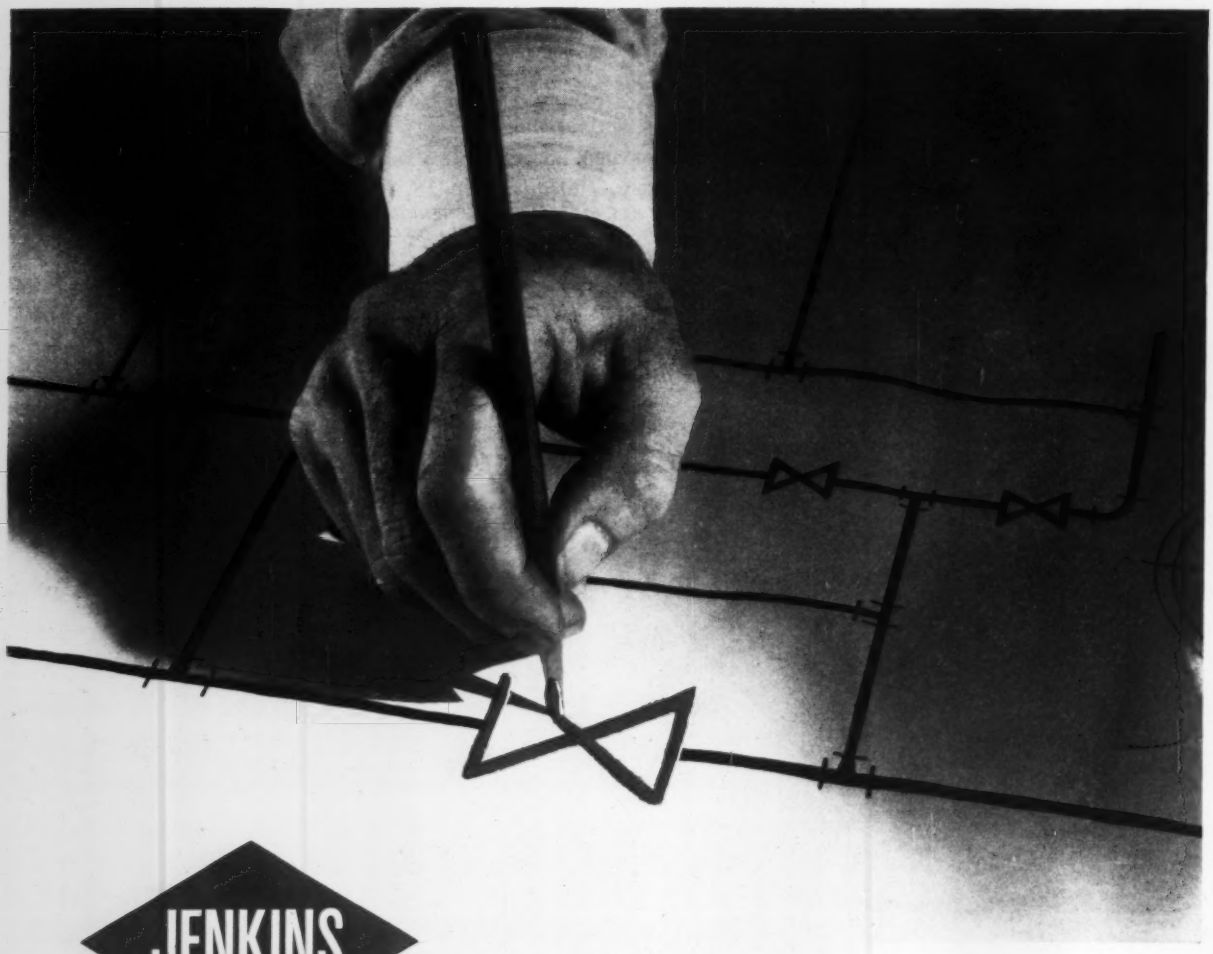

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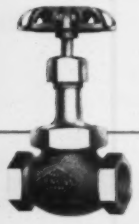

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NEW EQUIPMENT

Redesigned VA Varidrive

A new design in fractional to 1-hp, variable-speed drives, the Type 5 VA, U.S. Varidrive, has been released by U.S. Electrical Motors Inc. The new 5 VA Varidrive is compact in size and offers speed ratios up to 10:1, from 4 to 10,000 rpm. It is available in 1/4, 1/3, 1/2, 3/4 and 1 hp, 3 phase and single phase. 60 cycle.

To provide more precise settings than ever before, a new hand control assembly has been incorporated. Operated by a fluted knob, the new control turns with only 1/7 the effort of previous controls. Speed drift is prevented by a positive anticreep device.

For machine operations requiring only fractional to 1 hp. this new special type Varidrive is offered as a versatile, all-in-one power drive designed for rugged industrial service. It performs the work of a motor, speed changer, cone pulley or controller and gear box.

In the 1/4 hp size, the 5 VA is 14 1/2 in. high and 8 1/2 in. wide, and weighs but 63 lb. It is designed to occupy least cubical space. —K-1

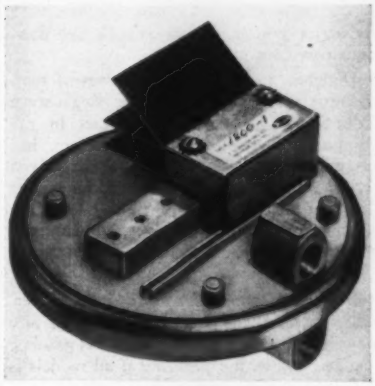
Oscillographic Recorders

Portable oscillographic recorders are being manufactured by the Sanborn Co. Model 320 two-channel direct writer, with a new paper take-up, occupies approximately 1 cu ft, yet provides broad d-c recording capabilities. Two other versions of the Model 320 are also available; Model 321 carrier type, and Model 322 low gain d-c recorder including zero suppression. These compact recording systems are designed for ruggedness and maximum usefulness in the plant, laboratory or field. —K-2

Gravity Conveyor

A new 15-in. wheel-type gravity conveyor for handling packages and other smooth, flat-bottomed materials is being produced by Hytrol Conveyor Co.

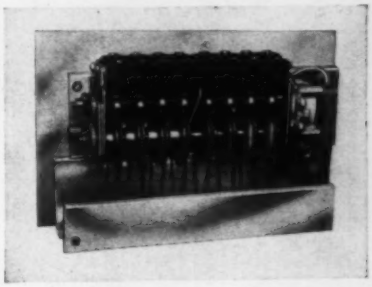
The 15-in. wheel model is designed for use in many flow systems, according to the manufacturer, and can be set up quickly with other Hytrol conveyors and accessories. It is available in 5 and 10-ft track sections and is made of galvanized steel or heat-treated aluminum frames. The load capacity ranges up to 1600 lb per 5-ft section of the straight steel tracks. Similar aluminum track capacity is 1050 lb and its weight is about one half that of the steel track. —K-3



Differential Pressure Switch

A new differential pressure switch, No. 1800 series, is now available from F. W. Dwyer Mfg. Co. The switch is a low cost, compact unit (only 4 in. dia) of excellent sensitivity, operating from differential pressures as low as 0.15 in. water with ranges up to 80 in. water. It will hold a set point through various total pressures and can be operated from plus, minus or differential pressures in any position. The unit can be applied almost universally for accurate, low-pressure sensing and control such as in cooling-coil defrost control, dust-collection systems, air filters, air curtain systems, etc.

Various arrangements of this pressure switch are available, from a basic unit incorporating only operating arm protection to switches with weather boot of neoprene, regular conduit enclosure or explosion-proof housing. Pilot lights, showing energized circuits, plus other features can easily be incorporated to meet specific needs. More information available in Bulletin No. E-40. —K-4



Bead Chain Timer

Complex sequencing problems are being solved with a new adaption of the simplest of electromechanical timing devices—the synchronous-motor-driven cam. Eagle Signal Co. has removed the cam and replaced it with a drive sprocket, in which an endless stainless-steel bead chain (not unlike the conventional key chain) is advanced. To establish the cam action which actuates the switch at the desired time, large beads are applied to the chain. These beads may be applied singly to give a momentary closure or in groups to produce a sustained closure. Vari-colored beads are used for coding. There is virtually no limit to the length of chain or timing ranges available.

This basic idea, which on the surface appears to be very elementary, has proved itself to be a highly versatile and accurate timing concept. Used in multiple circuits, as illustrated, microsecond timing and timing accuracy have been established.

The bead chain timer is not yet considered by the manufacturer as an entirely standardized item. It is available at this time on a semi-custom basis. —K-5

Speed Variator

Exceptional compactness has resulted by incorporating a motor with a mechanical variable-speed drive, manufactured by the Cleveland Worm & Gear Div., Eaton Mfg. Co. Utilizing an integral "pancake" style motor, the new motorized speed variator requires only slightly more space than an equally rated conventional motor. The new line is available in sizes from 1/3 to 15 hp. Motors are a-c radial air-gap design and conform to NEMA design "B" specifications.

Cleveland speed "variator's" unique design insures precise speed setting and repeatability. It provides variable output speeds with 9:1 and 6:1 ranges. Since it employs the rolling action of a series of balls, it permits smooth adjustment of the output speed while operating under load. —K-6

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Rota-Screw Compressor

A revolutionary concept in portable air compressors has been developed and produced by Gardner-Denver Co. In what the company believes is the first of its kind manufactured in the United States, Gardner-Denver announces a portable screw-type air compressor which is called the "Rota-Screw" compressor.

Thoroughly researched, tested and proven, the new compressor is replacing the company's present production of vane-type rotary portable compressors. Company eingineers believe the Rota-Screw design will revolutionize the portable compressor industry.

A time proved principle forms the basis for Gardner-Denver's Rota-Screw compressors. Air entering the intake port is drawn into the space between lobes of two helical rotors. The revolving rotors force the air into succeedingly smaller interlobal spaces, compressing the air in a single stage until full compression is reached. As air is expelled, the next groove comes into line with the outlet port to assure smooth free flowing air without pulsation.

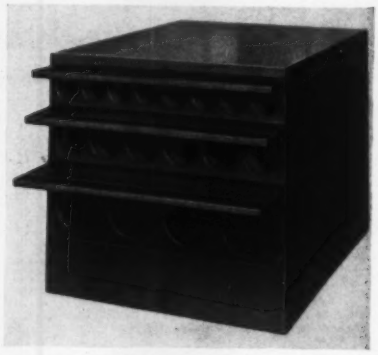
Designed to operate at extremes of temperature (−40 to 115F) the single-stage Rota-Screw has no metal contact in the compression chamber, and, therefore, has no wearing parts. Two rotors are driven by timing gears and are oil flooded for sealing and heat removal in compression. There are no blades, no vanes, no valves, no pistons or other reciprocating parts to replace or inspect.

Three models are available, the 900 cfm and 600 cfm powered by 6 cylinder Caterpillar diesel engines, and the 125 cfm size powered by a 6 cylinder Continental gasoline engine. Operating pressure of all models is 100 psi at 1800 rpm. Never before have such advanced features been available on portable compressors as those designed for the Rota-Screw. A Fail-Safe electrical system stops the compressor should any malfunction occur. —K–7

Sonic Height Sensor

Unique advances in the design and development of a wave-measuring device which insures the success of autopilot-controlled hydrofoil craft has been announced by RCA's Missile Electronics and Controls Div., which is now conducting extensive laboratory and field tests on the instrument.

The new device is a transistorized ultrasonic height sensor. In its hydrofoil-craft application, it provides instantaneous and constant measurement of the changing height of waves from crest to trough, enabling the craft to proceed smoothly and without loss through automatic adjustment as dictated by the sensor. —K–8



Filing Rolled Material

The Hamilton Mfg. Co. has announced a modern-modular approach to filing rolled tracings, prints and other rolled materials. The new Hamilton product "Moducor" provides exceptional flexibility in rolled filing equipment with varying tube dimensions to fit every size, type or activity of stored materials.

The Moducor system consists of four, six, and eight-tube modules in 4, $2^{5}/_{8}$ and $1^{7}/_{8}$-in. dia tubes. All modules are of a standard width to permit stacking any size modules for varying storage and activity requirements. Individual tubes are paper laminate, foil wrapped with steel ends for maximum strength—moisture, dust, and smoke resistant. Tubes are anchored mechanically in a sturdy metal frame to positively prevent accidental tube removal while permitting easy insertion of a new tube without requiring tools, paste or glue. —K–9

Telemetering Oscillator

The production of Model CT10 telemetering sub-carrier oscillator system that provides a compact and reliable telemetering unit for operation with up to 12 variable-inductance transducers is announced by PACE Engineering Co.

The instrument's module case accepts six printed-circuit sub-carrier oscillator cards, which together with appropriate transducers may be tuned to any of the IRIG bands, 4 through 18 or optional bands, A through E. Included, also, is a dual-channel composite amplifier that receives the summed output frequencies from the inductance oscillators and feeds the transmitter.

Model CT10 systems are available for operation on any specified voltage, 6 volts dc to 50 volts dc at 48 ma, nominal current, and have frequency stability of ±1 per cent of the bandwidth for ±5 per cent change in operating voltage. Weighing less than 2 lb, the Model CT10 is only 3 in. × 3 in. × $3^{3}/_{4}$ in. It will withstand vibration of 35g, 50–2000 cps; shock and acceleration of 200g, any axis, with less than 1 per cent bandwidth change. —K–10

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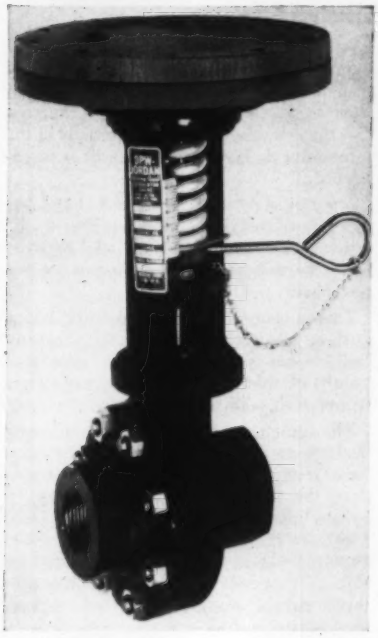

Control Valves

Control valves are now available in cast steel as No. 670 and stainless steel as No. 770 from OPW-Jordan. Stocked in 1/4, 3/8, 1/2, 3/4, 1, and 1 1/4 in. capacities for immediate delivery in both cast steel and stainless steel bodies. Complete stainless steel trim is standard with linear-flow-characteristic sliding-gate seats. These valves are suitable for a wide range of tough chemical applications as well as steam, air, water, oil and gas; self-operated or controller-operated, for 300 psi and 500 F WSP service. Bulletin JNP-7 shows cutaway view, materials of construction, features, sizing charts, flow curve, dimensional drawing, explanation of sliding-gate seat, ranges, ratings, and complete engineering specifications and prices. —K–11

Motor Insulation

The Louis Allis Co., has announced the addition of "Capsulex" insulation system, that has been especially developed for encapsulated formed coils used in large a-c motors ranging in sizes from 200 to 2000 hp.

The new insulation system provides added protection to windings against moisture, chemicals, oils and abrasive contaminants, allowing increased life for open motors used in unfavorable environmental conditions.

Capsulex is available in open, drip-proof, splash-proof, and weather protected motors built in frame sizes larger than 445U—for operating voltages of 208 to 5000 volts. Request Bulletin No. 3700. —K–12

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DUST CONTROL BULLETINS

You can save time when planning and save money when buying if you'll send for these DAY dust control bulletins. Each contains valuable information about dust control equipment and systems. Here's general information plus useful technical data and specifications. Ask for any bulletins which interest you — they're free. Check coupon below and mail toDAY.

BULLETIN G-30—Describes the DAY Type "RJ" filter. An all purpose, versatile unit. Bulletin gives operating features, dimensions and specifications.

BULLETIN D-20 — Dual-Clone dust separators — noted for their low resistance and high cleaning efficiency. Easy to install, no maintenance, no moving parts.

BULLETIN I-585 — Industrial Fans. Complete with helpful selection charts, capacity tables, dimensions and specifications. Information on special types and arrangements included.

BULLETIN F-75 — Reverse Jet Dust Filter Facts. Complete with specifications, typical equipment layouts, capacity and performance tables for DAY type "AC" filter.

BULLETIN N-578 — Gives complete information about Style "A" rotary valves. Construction features, specifications, dimensions and applications.

"SCHLITZ DEFEATS DUST" — FOOD ENGINEERING magazine reprint describes all out dust control for 3½ million bushel Schlitz grain elevator. Request Bulletin "Schlitz" Defeats Dust."

"EFFICIENT DUST SNATCHERS" — Bulletin describes DAY's part in providing maximum safety and good housekeeping for starch packing building of large food processor.

BULLETIN 510—DAY Unit Dust Collectors. Complete, low cost unit designed for plants or applications where central dust control systems are not practical.

BULLETIN 576 — "HV" heavy duty dust separator. Rugged construction and lower initial cost than many light gauge galvanized type cyclones.

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☐ Bulletin G-30 ☐ Bulletin F-75 ☐ "Efficient Dust Snatchers"
☐ Bulletin D-20 ☐ Bulletin N-578 ☐ Bulletin 510
☐ Bulletin I-585 ☐ "Schlitz Defeats Dust" ☐ Bulletin 576

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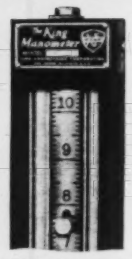
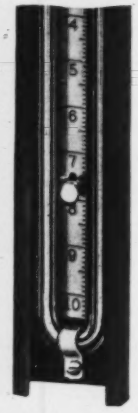


The liquid-filled U-tube is unequaled in simplicity and inherent accuracy. It's the *primary standard* for measuring pressure, and for checking pressure gauges.

All King Manometers, regardless of configuration, are *U-tube instruments*, with no mechanical moving parts. They give unfailingly accurate measurements in plant or lab - - permit exact duplication of pressure or flow conditions.

King Manometers are inexpensive; easy to install; require minimum maintenance. Available in the following types, for every service:



U-Type Manometers
Single Cleanout; Double Cleanout; with 3-Valve Manifold; Inverted U.

Well-Type Manometers
Low-Well; Raised-Well; Adjustable-Well; Barometric; Instrument Test; Flowmeter.

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MANOMETER CATALOG 2008
explains basic principles; simplifies manometer selection; shows complete line of manometers, accessories and indicating liquids. Write for it.

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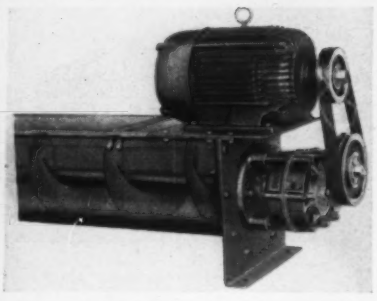

Screw-Conveyer Drive

A compact screw-conveyer drive especially designed for short conveyer flights and low horsepower requirements is announced by Dodge Mfg. Corp.

Identified as Series 100, the new product extends the present line of Dodge screw-conveyer drives introduced in 1958 and now widely used in industry. Series 100 drives are offered in two speed ratios: 8:1 for up to 6 hp at 225 rpm, and 18:1 for up to 3.8 hp at 100 rpm.

The new unit consists of a double-reduction speed reducer with packing gland and driving shaft which mounts on a trough end. Trough ends are also available.

As in other Dodge speed reducers, maximum efficiency is assured through the use of heat-treated helical steel gears and pinions, all rated according to standards of the American Gear Manufacturers Association. Ask for Bulletin 601. —K-13

Piping System Template

A new piping system welding fitting template has been announced by Bonney Forge and Tool Works. Including the most commonly used welding fitting shapes, the template was prepared in co-operation with and for piping designers, to speed design and drawing time on welded piping systems. The templates are available, without charge. —K-14

Nuclear Fuel Elements

Development of a method of fabricating nuclear fuel elements at reduced cost has been reported today by The Babcock & Wilcox Co. The new technique calls for the vibration of atomic fuel of uranium-dioxide powder into thin hollow rods which are forged, or swaged, to the final diameter. In the process, the UO_2 powder is compressed to the required density.

This method of producing fuel elements eliminates such costly manufacturing processes as pressing, sintering, grinding, and inspection of individual pellets. Most oxide-type fuel elements now in use consist of a metal container of thin-walled tubes, or rods, filled with prepressed pellets of uranium powder. —K-15

Stainless Steel

A new and even more corrosion-resistant stainless steel has been developed by Allegheny Ludlum Steel Corp. after two years of intensive development work. It is expected that the new alloy will be used initially in the automotive industry for which it was developed.

The new alloy is called Type 433 and has additions of molybdenum and copper to the automotive standard stainless steel of Type 430. Patents have been applied for on this new grade.

This announcement, of Alloy 433, brings to three the major developments Allegheny Ludlum has made within the past four months of either new materials or processes for use in the automotive industry.

The automotive industry subjects stainless steel to some of the most severe tests. Among these tests are the Cass test, the crevice tests, the salt spray test, the salt slag alternate immersion test, and service tests. Allegheny Ludlum's new stainless steel–Type 433–passed all of these tests unusually well. The service tests by automotive producers are still continuing, and final reports on these will not be in for six to eight more months. —K-16

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Solenoid Valves

Fluid Power Accessories, Inc., has developed a new line of two-way solenoid valves for oil pressures to 3000 psi. Two types are available—normally open and normally closed. Both are pilot-operated, poppet-type valves in cartridge form. They can adapt to any type of manifold or subplate. All standard a-c or d-c solenoids are interchangeable. Only two moving parts, poppet and plunger, make these valves less susceptible to malfunction due to contaminated systems.

All valves have free reverse flow in either energized or de-energized position. Hardened, ground, and lapped parts with oil-immersed plunger assure long trouble-free operation. Many modifications to specific requirements are possible. **—K–17**

Heat Exchangers

Reflecting the company's long experience in building custom shell-and-tube heat exchangers for the petroleum, chemical and other industries, the new line of Griscom-Russell pre-engineered exchangers using standardized components are available in three tube lengths; 16, 20 and 24 ft. Shell diameters range from 21 to 45 in. nominal id by approximately 1 in. increments. Two, four or six passes of the tubeside fluid are available. Standard design pressures are 150, 300, or 450 psi tubeside and 150, 300, or 450 shellside. Thus, one of these standard units can be expected to meet all but the most unusual requirements. Acceptable modifications from standard construction provide the flexibility of custom design in meeting unusual specifications of large users. **—K–18**

Hand Pumps

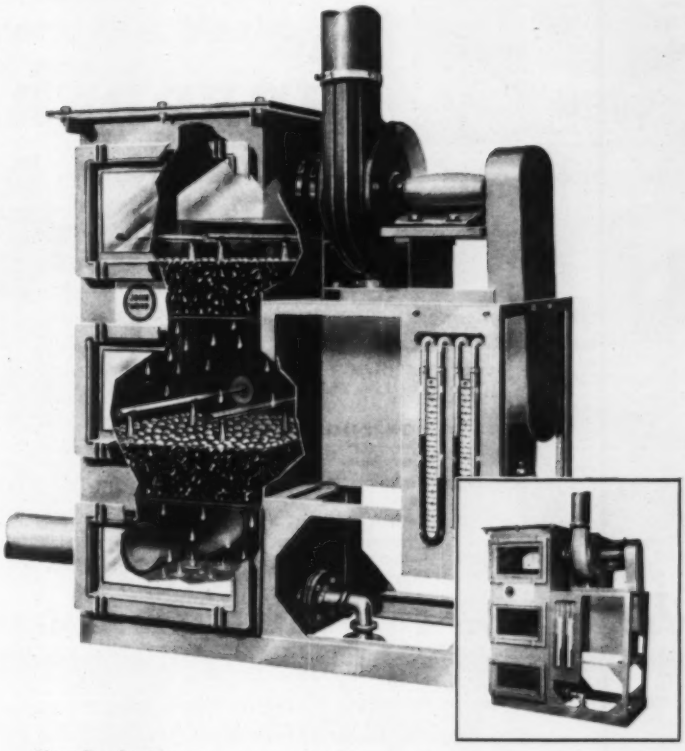
A new double-acting hand pump series by the Wayne Pump Co. handles 15 common classes and liquids with what the company terms "total reliability."

Series 110 units are equipped with double diaphragms which keep the liquid sandwiched between them instead of permitting contact with the body of the pump. The pump body is corrosion resistant and the diaphragms as well as the valves are fabricated of a deterioration resistant synthetic-rubber material, said to impart nearly indefinite operating life. Diaphragms contain integral O-ring seals which provide positive antileak protection. Pumping is accomplished on both push and pull strokes.

Of particular note is a new recording counter which has a totalizer reading up to 9999 gal and a resetable counter which reads to 99.9 gal. It takes approximately 100 push-pull strokes of the pump to move 78 gal. of liquid. **—K–19**

FOR CONSULTING ENGINEERS
TURN TO PAGE 195

New Ideas On Dust And Fume Control



New Products:

John Wood Interphase Flooded-Bed Scrubber

This unique approach to the removal of fumes, vapors and dust from ventilation systems offers a new high in operating efficiency. In fact, efficiencies in adsorption and absorption of NO_2 exceeding 95% and of HCl of virtually 100% have been obtained.

Two horizontal beds operating under flooded conditions break the air stream into bubbles 1/16 inch in diameter. Completely surrounded by the scrubbing liquid and subject to impaction forces caused by continuous change of direction, the bubbles break up. Rapid absorption is the result.

The John Wood Flooded-Bed Scrubber is a compact, integrated unit. Construction is corrosion proof and provides easy access for servicing.

New Engineering: The complete line of John Wood equipment also includes Venturi Scrubbers, Multi Cyclones, Involute Cyclones, Fabric Filters and combination units. Extensive John Wood laboratories are available for advanced research on your air pollution problems.

New Service: John Wood Air Pollution Control is fully programmed from analysis of existing conditions to equipment installation. Frequently economies result that make the installation self-liquidating through lower maintenance and replacement costs.

Write for engineering assistance or specific product information. An air pollution preliminary analysis kit is available without obligation.

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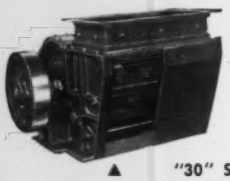

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Asphalt	Cryolite	Pitch
Bauxite	Fertilizer	Soda Ash
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Electro-Magnetic Brake

Stearns Electric Corp. announces the new 46,000 series brake. The brake operates on alternating current and is flange mounted. The brake is available completely enclosed in a housing with torque ratings of 500, 750 and 1000 lb-ft.

Some of the benefits offered by this new series are unusually high thermal capacities and extremely low WK^2. Its unique construction enables this series to compare favorably with more cumbersome stopping methods in regard to frequency of operation and thermal capacity.

The familiar Stearns "unitized" construction is retained. The entire operating mechanism is attached to a single plate facilitating disassembly and assembly for maintenance. Since the brake is a-c operated, control requirements are simplified, thus reducing cost. Need for readjustment to compensate for lining wear can be determined visually from outside the enclosure. Manual release-automatic reset is included. Standard motor shaft lengths, or through shafts can be accommodated. Ductile-iron construction and corrosion protection make the brake well suited for shipboard use. Floor-mounted models are also available. Literature is available. **—K-24**

Materials Tester

Extra large sections of materials can be easily positioned and tested in this W. C. Dillon & Co. Model LW extra wide tester. Standard width between the uprights has been increased approximately 80 per cent, from $8^3/_4$ to $14^1/_2$ in. In addition to this extra wide work area, four daylight openings are available (12, 20, 30, 40) to permit fixture travel in excess of the greatest anticipated elongation.

These new Dillon instruments are made in seven capacities: 0-250, 0-500, 0-1000, 0-2500, 0-5000, 0-7500 and 0-10,000 lb. Tests of tensile, transverse, compression and shear can be made on materials with tensile strength varying from only a few pounds to as high as 400,000 psi. **—K-20**

Centrifugal Pumps

New sizes have been added to the Model 3405 line of single-stage, double-suction centrifugal pumps manufactured by Goulds Pumps, Inc. Thirty-four sizes are now available to provide capacities from 100 to 6400 gpm with heads up to 525 ft. A choice of grease or oil-lubricated bearings, wide degree of interchangeability of parts, availability in stainless steel and ductile iron, are among the many features of this highly popular group of pumps. Complete specifications, interchangeability chart, performance curves and dimensions are shown in new Bulletin No. 721.6. **—K-21**

Explosion-Proof Valves

Skinner Electric Valve Div. Skinner Precision Industries, Inc., has announced a line of 3-way explosion-proof solenoid valves with a $^1/_2$-in. main orifice and $^1/_2$-in. NPTF for use in hazardous locations. These new high-flow valve types are available normally open, normally closed and directional controlled, with operating pressure differentials of 5 to 150 psi.

These explosion-proof valves are UL approved for Class I Group D use in atmospheres of gasoline vapors, for Class II Group F, coal and coke dust, and Group G grain dust.

The $^1/_2$-in. explosion-proof valves of the L series have naval forged brass bodies and internal parts of brass and stainless steel. They are available in a wide range of voltages and frequencies. **—K-22**

Weir Drive Motor

The Electro Products Div. of Western Gear Corp., has announced the design and manufacture of a Weir drive motor for use in nuclear-radiation environment. Identified as Model 36V58RP143, it has an imput of 115 volts, 3 phase, 400 cycle, with an output of 150 oz-in. at 12 rpm continuous duty. The temperature rise is 40 C maximum. It measures 1.5 in. in diameter by 3.31 in. long not including shaft extension. It weighs 15 oz. **—K-23**

Magnetic Shaft Angle Encoder

The United Aircraft Corp. Norden Div. has developed and now is producing a noncontacting Gray code magnetic shaft angle encoder, one of the smallest in this field.

The Norden encoder, BuOrd size 18, synchro mount, also is one of the simplest yet designed. It provides accurate readout at 10,000 rpm and has exceptionally low starting and running torques. It has a nonambiguous code and is mechanically interchangeable with existing brush-type encoders. This new encoder, with its virtually unlimited life, is tailored for installations where long use, speed, and environmental conditions cannot be met by brush-type encoders, for servo and shaft position encoding for low-to-medium resolution, and for single turn and high resolution multiturn applications. **—K-25**

Molding Compound

Future Chemicals is offering a free "desk-test" kit of Copy-Cast, the new molding, bonding, filling, and shape-making compound.

Each sample contains enough Copy-Cast to make a test application right at one's desk. The manufacturer claims that this product is resistant to acid, alkali, grease and solvents; non-shrinking and non-crumbling, controllable curing, outstanding electrical resistance; holds its shape and can be worked and finished with ordinary tools. **—K-26**

KEEP INFORMED

BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Centrifugal Pumps

A new line of single stage centrifugal pumps announced by Goulds Pumps, Inc. provides the optimum in interchangeability of pumps and parts. Designed especially for the chemical processing, petrochemical and petroleum-refining industries but equally adaptable for use in any industry that must handle chemicals—corrosive or abrasive—cold or hot (−350 to 500F)—clear liquids or slurries. The eleven sizes in the line provides capacities up to 775 gpm and heads up to 300 ft.

The complete line of eleven pumps is stocked in three standard constructions: Ductile iron, 316 stainless steel and Gould-A-Loy 20. It is also available in any machinable alloy to meet special requirements.

New 16-page Bulletin No. 725.8 gives bearing life, and shaft deflection data, a frame selection chart as well as usual performance, specifications, construction details, and dimensions. —K–27

Flexible-Gear Couplings

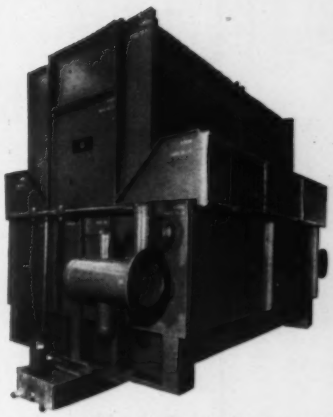
The Flexible Coupling Div. of Sier-Bath Gear & Pump Co. has announced the development of a new lubrication seal for its complete line of flexible-gear couplings.

In the new seal, the product of a two-year research and development program at Sier-Bath, two separate heat-treated steel washers are bonded together—one inside the other—by means of a flexible hinge of Buna-N. The inner washer provides a press fit on the coupling hub and the outer washer an equally snug fit in the seal cavity cut into the coupling sleeve. Regardless of the relative motion of the hub in the sleeve, the flexible neoprene hinge permits the washers to maintain their individual press fit and actually seal in lubrication at $1^1/_2$ deg misalignment at operating speeds in excess of 5000 rpm. The steel washers also prevent the seal from being damaged by the hub teeth during periods of momentary or prolonged end thrust of the shafts. —K–28

Profile Grinders

Rice Pump & Machine Co. redeveloped line of profile grinders, extends the range of precision grinding to include grinding of die clearances, cams and contours; plus a wide variety of finish-grinding work. Some of the newly added features include the hinged access door to facilitate interior maintenance; a larger serrated table (12 in. × $13^1/_2$ in.) with an improved U-bracket support, with a 4-way tilt. The wheel dresser is attached to the underside of the table, has no loose parts to require preassembly, and is always ready for action. Spindle speeds are available in 20,000, 30,000 and 35,000 rpm ranges for the single speed machines and in 20,000–30,000 and 20,000–35,000 rpm for two speed machines. Request Bulletin PGI 38. —K–29

You Get EXTRA SAVINGS From This Method of Compressed Air After Cooling



Cooling water savings and power savings quickly repay the cost of the Niagara Aero (air-cooled) After Cooler for compressed air or compressed gases. In addition its long life and the labor-saving simplicity of its maintenance give you an extra profit in comparison with water-cooled surface contact methods.

With the Niagara After Cooler the heat of compression is removed and dispersed into the atmosphere by the evaporation of a very small amount of water. The compressed air temperature is always brought below that of the atmosphere surrounding your air lines, so that no further condensation can take place.

Large users of compressed air for plant services or processes choose Niagara Aero After Coolers for their dependable durability. They have been making good records of service for over 25 years.

Write for Bulletin 130.

NIAGARA BLOWER COMPANY
Dept. ME-5, 405 Lexington Ave., New York 17, N. Y.
Niagara District Engineers in Principal Cities of U. S. and Canada
Circle No. 150 on Readers' Service Card

Hydraulic Clutches

Rockford Clutch Div. of Borg-Warner recently introduced a line of power shift hydraulic clutches. Power shift clutches are now available as components for a wide range of transmissions and machinery. The clutch design permits manufacturers to tailor their equipment to individual customer requirements.

Rockford's new line of clutches is available in 6 sizes to handle torque loads from 1000 to 10,000 lb-ft, engines up to 1000 hp, and speeds up to 5500 rpm. The dual-drive design gives end-to-end shifting with extremely smooth and fast engagements.

These versatile clutches have been designed to drive off-highway wheeled and track-laying vehicles, switching locomotives, marine gears, cable and winch drives, prime movers, front-end loaders forward-reverse units, and machine tools. —K–30

Oil Filter-Reclaimer

The Hilliard Corp. has brought out an oil filter-combination reclaimer which consists of a motor pump set of practically any capacity required for forcing the oil through the filter with either all of this oil or part of it being diverted to the oil reclaimer for final polishing and removal of moisture, water, and other volatile contamination. Piping is arranged so that the oil reclaimer or filter alone can be operated where straight filtration is required or in combination, when the removal of volatile material and heavy solids contamination is necessary. This flexibility of operation permits the unit to be used for restoring practically all types of lubricating and industrial oils to new oil condition. Various types of filtering materials are available to handle specific types of oil. Applications include internal combustion engines, compressors, vacuum-pump lubricating and sealing oil, turbines and all types of electrical insulating oils. Request Bulletin No. 114. —K–31

HEART DISEASE #1 Enemy
GIVE ®
Defense #1
HEART FUND

"LUBRIPLATE LUBRICATION IS AVAILABLE AT OUR DEALERS"

Says—
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The Studebaker-Packard Corporation, builder of the LARK, express their satisfaction of LUBRIPLATE Lubricants by having these fine lubricants packaged under the Studebaker-Packard trademark and made available for use by the service departments of their dealers.

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE LUBRICANTS WILL IMPOVE ITS OPERATION AND REDUCE MAINTENANCE

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Fiske Brothers Refining Co.
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Circle No. 85 on Readers' Service Card

KEEP INFORMED

NEW EQUIPMENT
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Metallic Static Face Seals

Haskel Engineering & Supply Co. has announced a new line of metallic static face seals designed and manufactured specifically to meet the high-pressure and extreme temperature requirements of systems in missiles and high-performance aircraft.

Wherever static sealing problems exist which elastomers cannot solve, the new HS series seal can be utilized to provide zero leakage at a wide range of temperatures from −450 to +2000 F and pressures to 20,000 psi. Liquids and gases are sealed in valves, actuators, missile and rocket engines, couplings, filters and in any catagory where temperature, vibration, pressure and expansion are critical.

The new HS series seals are manufactured in a wide range of materials: Inconel X, age-hardened; A-286, age-hardened; 17-4PH to H1150 hardening; 7056-T6 aluminum; 18-8 CRES, heat-treated; tantalum, annealed; most of these may be obtained with platings of silver, gold, indium, Teflon, Kel-F, copper, etc.

The HS seals are lapped to provide flatness and smoothness of the sealing faces. A flat surface with a finish of 32 rms or better is adequate to provide a mating surface. The seals incorporate an integral spacer which avoids the problem of controlling groove depth closely. Installation is accomplished by merely indexing the seal to one mating surface and bringing the opposing surface against the seal. High torque loading is normally not required. Design strength necessary to contain unit pressures usually provides adequate force to seat the seal for proper performance.

The HS seal is reusable, light weight, has no storage or age-life problems and is available in a wide range of sizes from miniatures to large diameters. A new catalog giving full details on design, materials, sizes and installation for the complete line is available on request. —K-32

Precision Balls

Precision balls of special materials are now available in both prototype and production quantities from Industrial Tectonics, Inc., Ball Div. Among the newer materials are boron carbide, titanium diboride, glass-filled Teflon, Indox I, irradiated polyethylene, ferrites, synthetic rubies and sapphires, tantalum, titanium carbide, and high-density aluminum oxides.

Balls of these materials greatly extend the range of possible aplications in cases where temperature and load extremes, corrosion resistance, magnetic or nonmagnetic qualities, dielectric properties, or controlled density are of major importance.

Balls of high-purity metals for research and development purposes can be furnished in a wide range of sizes, tolerances, and surface finishes. —K-33

Mechanical Differential

A miniature differential, designed for loads up to 75 in-oz and speeds to 3500 rpm, has been announced by Bowmar Instrument Corp. The new differential, Model X-1943, is ideally suited for use in servo systems and for integrating mathematical functions in computing equipment.

Employing super precision bevel gearing, backlash is held to $1^1/_2$ min with a 0.5 in-oz checking load; however, starting torque is kept to a relatively low value of 0.1 in-oz. The precision bevel gears are axially adjusted during selective assembly and testing, so that backlash and other operating characteristics are held to very close tolerances in large or small production quantities.

Various operating configurations are made possible as a result of the differential's hollow shaft construction. This flexibility makes the new differential valuable as a breadboarding or a prototype component as well as for production applications.

All parts of the differential are stainless steel. Materials and finishes may be varied to conform to applicable military specifications. Bowmar states that optimum accuracy and rigidity are obtained by mounting the gears and pinions on stainless steel duplexed bearings.

The X-1943 can be supplied in a wide range of end gear ratios to satisfy various operating requirements. —K-34

BUSINESS NOTES

Load-Control System

A contract for a Bailey Meter Co. 720 economic load control system that will automatically control power generation equal to demand and allocate the system generation to the units under control to achieve most economical operation has been received by Bailey Meter Co., Cleveland, Ohio. The load-control system will be installed at three plants of Columbus and Southern Ohio Electric Co. of Columbus, Ohio.

The Bailey system will automatically control frequency and/or tie-line load as well as distribution of load on incremental rate basis between eight generating units at three stations–Conesville, Picway, and Poston. The master control and system dispatcher's console will be located in the dispatcher's office in Columbus. Frequency-type telemetering over telephone lines and power-line carrier will connect it to the individual control equipment at the stations.

KEEP INFORMED

BUSINESS NOTES
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Represents Bauer Compressor

Norwalk Co., manufacturers of high pressure, air and gas, compressors since 1864, has been appointed the sole distributor to U. S. industry of the famous line of Bauer compressors, which are manufactured in Western Germany.

Bauer compressors, which will supplement the full range of heavy Norwalk custom-production compressors, are smaller, high speed and air-cooled units. Exclusive American representation covers both sales and service. Full details can be received by contacting the South Norwalk office of the Norwalk Co.

Koppers Plant Expansion

To meet an increasing demand for corrugated container machinery, the Metal Products Div. of Koppers Co. has announced that its manufacturing facilities for these products are being expanded at a cost in excess of $300,000. The division's Container Machinery Dept. has two manufacturing plants, one located in Glenarm, Md., and the other in Bordentown, N. J.

The major item included in the expansion is an extension to the Glenarm plant, providing an additional 16,000 sq ft of manufacturing floor space.

Principal products of Koppers Container Machinery Dept. are Hooper printer-slotters, produced at Glenarm, and Swift combiners, produced at Bordentown.

LATEST CATALOGS

Spray Nozzles

Industrial, high-pressure spray nozzles are described and capacity charts given in a bulletin issued by the Industrial Sales Dept., John Bean Div. of Food Machinery and Chemical Corp. Some of the applications of these nozzles are to spray concrete curing, to wash insulators, suppress coal dust, clean paper mill rolls, to spray castings, wash concrete trucks, logs and for many other industrial uses. —K-35

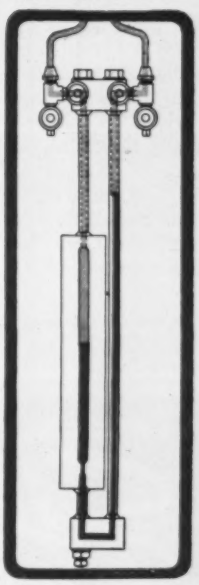
Relief Valves

Two new automatic temperature pressure relief valves for water heaters have been announced in Bulletin 1-NFLX-1 by A. W. Cash Valve Mfg. Corp.

An outstanding feature of these two types is the extra thin extension thermostat which places the element in the hottest water, yet does not restrict flow. —K-36

This green liquid column could be your boiler water level –

a true check on your boiler's safety by the Reliance EYE-HYE



Easy to read, like the conventional boiler gage, the illuminated green fluid gives you even sharper indication of where water levels stand. EYE-HYE can be placed at any vantage point, on panel, post or wall. Manometric operating principle insures perfect measurement, sensitive to slightest level changes.

Easy to install, easy to maintain. With no mechanical working parts to fail – no gears, magnets, diaphragms or linkage – it's simple, fool-proof. No adjustments. Each EYE-HYE is factory-calibrated to *your* water level range and working steam pressure.

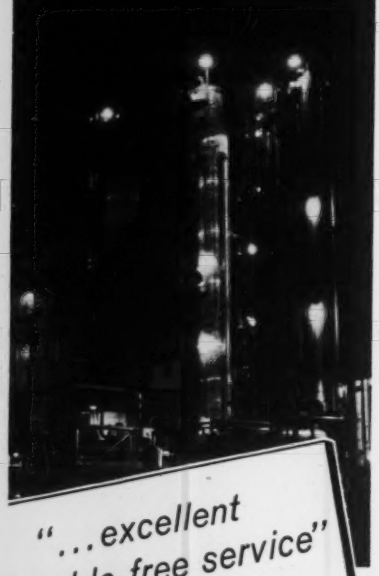
Various EYE-HYE models fit any remote gage need – for boilers, tanks, storage vessels – any visibility length, any working pressure. Wide vision facility makes reading visible from wide area . . . For safe, sure check on boiler water levels, write the factory for full EYE-HYE information.

The Reliance Gauge Column Co. • 5902 Carnegie Ave., Cleveland 3, Ohio

Reliance® BOILER SAFETY DEVICES

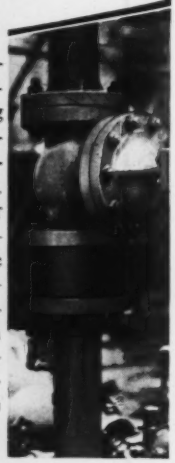
Circle No. 111 on Readers' Service Card

For the Savannah Plant
of
SOUTHERN NITROGEN CO.



"...excellent trouble-free service" against SURGE PRESSURES

Handling hot potassium carbonate requires safeguarding pumps and piping systems against dangerous pressure surges. Eight Williams-Hager Silent Check Valves—similar to the one shown at right—guard Southern Nitrogen's Savannah Plant by operating *instantly* when flow reversal starts or when flow is zero.



Write for Bulletins: #654 on Valves; #851 on Cause, Effect and Control of Water Hammer; #659 on Pressure Loss Tests.

WILLIAMS • HAGER
Silent
Check Valves

The Williams Gauge Company, Inc.
149 Stanwix Street • 2 Gateway Center
Pittsburgh 22, Pa.
Our 75th Year • 1886-1961
Circle No. 137 on Readers' Service Card

KEEP INFORMED

NEW EQUIPMENT
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Valve-Position Transmitter

The Model AVPT pneumatic valve-position transmitter, a compact, accurate device for translating position into a proportional output pressure is discussed in a revised bulletin recently issued by B-I-F Industries, manufacturers of process instrumentation, equipment and systems for positive control of materials flow.

Operating on the force-balance principle and designed for either rotary or straight-line motion, the AVPT transmitter is especially suited for countless applications in which the knowledge of the position of a remote mechanism is important for accurate control of processes.

The two-page bulletin contains photographs, dimensions, and specifications. Also included are application examples for the use of the AVPT transmitter. **—K–37**

Hard Cemented Carbide

Profitable utilization of high rigidity in a material that has three times the stiffness of hardened steel is spot-lighted in a new 16-page pocket sized booklet prepared by Kennametal Inc.

Featuring "$E = 94 \times 10^6$" in the title and headlines, the booklet gives typical examples in which this high YME (Young's modulus of elasticity) of Kennametal hard cemented carbide is particularly advantageous. These include components for chemical processing equipment, ordnance, aircraft, missiles and rockets, and for metal cutting and metal-working. **—K–38**

Welding Stainless Steel

Information concerning techniques for welding stainless steel is contained in Lincoln Electric Co. new Bulletin 7300.2 entitled "Arc Welding Stainless Steel." This bulletin gives physical poperties, structure, and welding characteristics of the different types of stainless steels. It also has a chart listing deposit properties and electrode recommendation tables for the different types of stainless steel. **—K–39**

Industrial Heating

As an appendix to its current Chromalox industrial electric heating catalog, No. 60, Edwin L. Wiegand Co., has announced new catalog supplement CS-600.

The new supplement contains specifications and product illustrations of Chromalox electric heater bands, air heating elements, blower-type heaters, immersion units, engine heaters, mineral insulated heating cable, special radiant heaters for process and comfort heating, controls and various other elements and equipment. **—K–40**

High-Speed Presses

The Series M line of open-back inclinable presses arranged for automatic, ultrahigh-speed operation with progressive dies is described and illustrated in a newly published six-page Bulletin 54 issued by Niagara Machine & Tool Works. Included are standard specifications, die-space dimensions, and stroke-shutheight data for the complete line of 22, 35, 45, and 60-ton-capacity models. **—K–41**

Welded Fittings

Information on "Husky" steel welding fittings for Schedule 40 piping is contained in Catalog H-2 of NIBCO Inc. General specifications and acceptance guide are given for concentric and eccentric reducers, 45-deg and 90-deg elbows, straight tees and reducing tees. Technical data, performance, materials and properties are contained in the catalog. **—K–42**

Dust Collecting

Buell Engineering Co., has issued a 4-page bulletin describing its complete line of Buell-Norblo dust collecting, recovery, and classifying equipment.

Air pollution, material handling and classification, recovery of material from waste gases, and employee comfort are a few of the broad areas of application for Buell-Norblo equipment. **—K–43**

Turret Lathe

A bulletin illustrating and describing the Rivett 60 series precision turret lathe has been published by Rivett Lathe & Grinder, Inc. The bulletin highlights six Rivett innovations, with particular emphasis on the new "one motion control," and an automatic indexing turret which passes over the top of a double-tool cross slide. **—K–44**

Liquid Blending

Vari-Flo proportioners and new concepts in continuous line blending are detailed in Bulletin 650, released by Blackmer Pump Co. According to the bulletin, Blackmer employs the flow control principle of its Vari-Flo variable-volume pumps to develop complete proportioning systems economically. The new equipment is designed for applications involving total flow rates between 1 and 2000 gpm, with larger systems possible by adding more components. **—K–45**

Vibratory Feeders

General Kinematics Corporation has issued a 4-page brochure illustrating Para-Mount vibratory feeders. These feeders are available in two types: Adjustable rate for precise, remote, stepless control and feed rate; and fixed rate for constant-rate applications. Request Bulletin 611. **—K–46**

KEEP INFORMED

NEW EQUIPMENT
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Engines and Power Units

Waukesha Motor Co. has issued a power rating chart, giving a complete tabulation of horsepowers, speeds and loads for power units, embodying diesel, natural gas, butane, propane and gasoline burning engines of its manufacture. The ratings are for complete power units with all standard accessories—water pumps, intake and exhaust manifolds, radiator, fan and belt, and air cleaner. —K–47

Power Units

Power units incorporating engine (diesel, gas, or gasoline) plus generator plus controls are described and illustrated in a bulletin by Waukesha Motor Co. under the title "Enginators." The bulletin outlines the three factors to consider in selecting Enginators, the components involved, controls, basic data, and specifications. —K–48

Fire Pumps

A highly descriptive, illustrated, six-page bulletin, No. 401, showing cross-section drawings, typical installations, size and capacity charts, and detailed advantages of a Layne vertical fire pump has been issued by Layne & Bowler, Inc.

Both oil and water-lubricated types are shown complete with accessories to meet the Factory Mutual and Underwriters' Laboratories requirements. —K–49

Temperature Controls

Fenwal Inc. has issued an eight-page brochure, MC-195, describing its new "500" line temperature controllers and indicators. The brochure gives complete details of three models in the line and brief descriptions of other Fenwal instruments offering thermistor sensing.

Contents include complete electrical and mechanical specifications, available modifications, and illustrated descriptions of various major features of the units. Also included are details on how various units can be combined for multipoint control or monitoring with a variety of optional features. —K–50

Relief and Regulating Valves

To meet MPS-300 requirements A. W. Cash Valve Mfg. Corp. has developed a series of relief valves and water pressure regulators which are announced in Bulletin 1-FWL-1. The valves listed include T & P relief valves for automatic temperature-pressure relief for water heaters; Type FWL pressure relief valves for pressure-only relief in domestic water heaters, storage tanks, etc.; Type F-52, relief valves for hot water space-heating boilers, and Type E-23U and Type E water pressure regulators for domestic water service. —K–51

Precision Controls

A series of Hubbell Corp. precision controls is described and illustrated in a recent bulletin. These units, including reverse acting pressure adapter, dual pressure adapter, solenoid valves, air-actuated pilot, thermal compensating control, and others, are designed for the refrigeration and air-conditioning industry. —K–52

Cryogenic Storage

Storage of liquefied petroleum gases at extremely low temperatures is the subject of a 16-page brochure, "Cryogenic Storage Vessels," G-50, published by Chicago Bridge & Iron Co. The brochure describes design of double-wall storage vessels, insulation systems, materials of construction and accessories. Illustrations include drawings and photographs of several CB&I-built cryogenic storage vessels. —K–53

Spring-Tension Fasteners

"Spring-Tension Fastening Devices," a recently published brochure by Associated Spring Corp., summarizes in four pages the various classes of spring-tension fasteners. Illustrations show customized designs for clamps, clips, latches and locks, pins, retainers, snap rings, hooks and holders, catches, spring washers, hangers, and collars. Case-history examples demonstrate how spring-like flat stampings can simplify design, cut costs, and improve reliability. —K–54

Flowmeter Kits

Four variable-area flowmeter kits, each containing meters of various sizes for a wide range of flow measurements, are described in a four-page bulletin, No. 10A1010, released by Fischer & Porter Co.

The contents of each lightweight kit is given, along with complete data on performance, operational limits, capacities, etc. Two of the kits covered are of the laboratory type: One uses hose connectors, the other standard taper joints. The other two kits described, contain high-capacity flowmeters; one has rubber hose connections and clamps; the other is equipped with fully enclosed meters ideally suited for pilot-plant operations. —K–55

Abrasives

"Catalog of National Standard Abrasive Belts, Rolls, Sheets and Discs," by Carborundum's Coated Abrasives Div., lists standard coated abrasive products used throughout industry. All items listed in this standard catalog are maintained in stock at Carborundum warehouses by electronic order processing and inventory control. This is a customer tool to help cut costs and expedite service through use of standard catalog items. —K–56

GRAY BIMETALLIC PIPE PROVIDES CORROSION RESISTANCE AT FRACTION OF THE COST OF SOLID ALLOY SYSTEMS

Gray Bimetallic pipe provides all the fabrication and strength advantages of carbon steel with the corrosion resistance of the best alloy materials, and at a fraction of the cost of a solid alloy system.

In the Gray process, a seamless lining is hydraulically expanded into the base pipe, forming a tight bond due to differential contraction of the materials. For all practical purposes the bond is permanent. Bimetallic pipe can then be fabricated almost as easily as carbon steel. It can be butt welded, flanged and bent without damage to the lining or the bond.

The choice of materials for Bimetallic pipe is virtually unlimited. Base material is usually standard carbon steel in regular sizes and schedules, but this can be varied to meet any particular need. Linings are most frequently furnished in Monel, nickel and stainless steel, but the selection is in no way limited. All the alloys of nickel and copper as well as the reactive metals can be economically produced.

This wide range of materials available make Bimetallic pipe ideal for all applications where corrosion is a factor. It is well suited where product contamination or catalyst poisoning are problems.

Gray Bimetallic pipe provides the corrosion resistance of special alloys at only a small cost more than that of regular carbon steel piping. For complete details, mail the coupon below today!

GRAY Tool Company

P. O. Box 2291 • Houston 1, Texas

Gray Tool Company
P. O. Box 2291
Houston 1, Texas

Gentlemen:
Please send me more information about Gray Bimetallic pipe.

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COMPANY_____

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6114

Circle No. 64 on Readers' Service Card

KEEP INFORMED

NEW EQUIPMENT BUSINESS NOTES LATEST CATALOGS

High-Velocity Fans

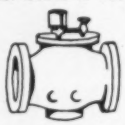
"Class III Fans" is the title of a booklet issued by Trane Co., containing descriptive and engineering material on fans for high-velocity, air-conditioning systems and industrial process application. Following the section devoted to illustrations and descriptions of the various types available and their special features and advantages, the booklet offers fan selection data, capacity tables, and roughing-in dimensions for all types. **—K-57**

Perfect ELECTRICAL Control

G-A CUSHIONED SOLENOID OPERATED VALVE

Where remote control valve operation is desired, specify and use the G-A Cushioned Solenoid Operated Valve that automatically opens or closes on any type of electrical impulse. The operating sequence—whether on open or closed circuit—can be made to suit your requirements. Sizes 2" to 36"

Bulletin W-7A has the complete story.



GOLDEN ANDERSON Valve Specialty Company

1223 RIDGE AVENUE, PITTSBURGH 33, PA.

Designers and Manufacturers of **VALVES FOR AUTOMATION**

Circle No. 62 on Readers' Service Card

Timing Equipment

A condensed illustrated catalog on its timing motors and time and torque controls has been published by the Haydon Div. of General Time Corp. The eight-page folder explains the company's specialized background in designing, developing, and producing these timing units and provides complete descriptions of various units and their applications.

The folder demonstrates the variety of timing motors and controls available from Haydon, including timing motors, time controls and indicators, electric brakes and clutches, military timers, and clock movements. Dimensions and special design characteristics of these compact electric timing units are included. **—K-58**

Hot-Water Converters

A 20-page, illustrated Bulletin 71 published by Niagara Weldments Inc., presents a new line of NiaWel hot-water converters designed specifically for space-heating service. In addition to listing complete specifications covering 114 models in 2 and 4-pass arrangements, the bulletin fully describes ASME construction of shells and removable U-tube bundles, metals and alloys available for special fabrications, and provides information for ordering models of other-than-standard size or construction. Also included is a unique, graphically illustrated method for selecting the correct size shell and heating surface. **—K-59**

Blast-Cleaning Barrels

Five heavy-duty Rotoblast barrels, with work capacities ranging from 15 to 102 cu ft, are described in Bulletin No. 705 published by Pangborn Corp. The features which make Rotoblast the most powerful blast-cleaning process available are illustrated with cut-away drawings, photos and sketches. Specifications and over-all dimensions are also outlined. Illustrated case histories show how heavy-duty Rotoblast barrels have reduced costs substantially at many different installations. **—K-60**

Super Vibrator

Martin Engineering Co., originator of the "Vibrolator" line of vibration inducers, is offering a new four-page folder entitled: "Big Shake Bulletin 1043." It describes air, electric, gasoline, and hydraulic-powered vibrators for use on railroad hopper cars, bunkers, chutes, laboratory testing, foundry shakeout, and other applications requiring a vibrator of great power and light weight. Action photos, drawings, engineering data and prices are enclosed. **—K-61**

KEEP INFORMED

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Study in Steel

The story of an unusual development in applying the qualities of steel is given in the booklet, "Study in Steel," released by United States Steel, Peter Muller-Munk Associates undertook the design of a line of steel office furniture, in the course of which a new form of "C" leg evolved, combining the three mechanical principles of steel—tension, compression, and cantilever. A variation, the "V" leg was also created.

The booklet illustrates and describes the wide range of modern furniture, not only office, which has been designed incorporating these developments.

Other applications of steel to modern structural design are also treated in the booklet. —K–62

Water Heater

Hot water with no pressure is the outstanding feature of the "M" heater described in a bulletin of Industrial Boiler Co. Model 140 with light oil burner and electronic safety controls is skid-mounted and hence the installation cost is negligible. It is of tube-type construction and is said to be 93.6 per cent efficient. This heater is available in standard capacities of 5000, 7500, and 10,000 gal. —K–63

Custom Rubber Molding

Publication of a four-page, two-color catalog illustrating and describing custom rubber molding of parts has been announced by Rubber Industries, Inc.

Described are the complete rubber molding services available from Rubber Industries such as molding of any color and shape rubber up to 36 in., rubber-to-metal bonding, plastisol dipping of parts and molding of precision parts for use by electrical and electronic manufacturers.

Diagrams show samples of parts the company has molded. Types of rubbers used and the qualities that can be manufactured into parts are described in detail. Easy to follow ordering information is also given. —K–64

Wire Fabric Slings

Union Wire Rope, subsidiary of Armco Steel Corp., is distributing a handbook under the title of "Tuffy Slings."

The qualities of "Tuffy" slings are due to the patented 9-part machine braided wire fabric construction, which combines great flexibility with extra toughness. The handbook tabulates a wide range of sizes, capacities, and fittings for "Tuffy" slings and illustrates diagrammatically the correct slings to use for a great number of applications. —K–65

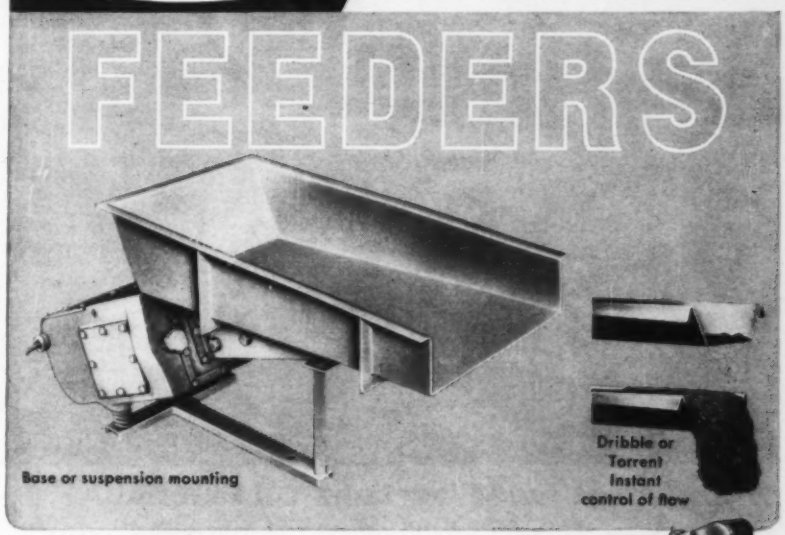
Pressure Controls

A data sheet on "Pressure Controls" has been prepared by Mercoid Corp.

This unit is available for use from 500 to 5000 psi, in indoor, outdoor, or hazardous locations. Features of the control include external adjustments, visible calibrated dial, visible settings, hermetically sealed mercury switch. —K–66

HANDLE BULK MATERIALS AT LOWER COSTS

SYNTRON VIBRATORY FEEDERS



Move bulk materials at constant, dependable, instantly controlled rates

Syntron Vibratory Feeders provide the most efficient and economical method of conveying bulk materials. They have proven for more than 30 years their ability to handle most types of bulk materials — fine powder to large lumps — hot or cold—dry or damp—in densities from 400 pounds to 6 pounds per cubic foot.

The simple electromagnetic drive unit produces 3600 vibrations per minute, assures continuous, dependable operation with a minimum of maintenance. The finger-tip control of material flow enables Syntron Vibratory Feeders to effectively fill the production gap between storage and process operation.

Syntron Vibratory Feeders are available in wide range of feed capacities, with above or below deck magnets, flat pan or tubular troughs, base or suspension mounting.

Syntron Vibratory Feeders are the answer to lower bulk materials handling cost.

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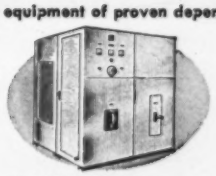
"Other Syntron equipment of proven dependable quality".

Flow Control Valves


Rectifier Power Units

Hopper Level Switches

Circle No. 123 on Readers' Service Card

KEEP INFORMED

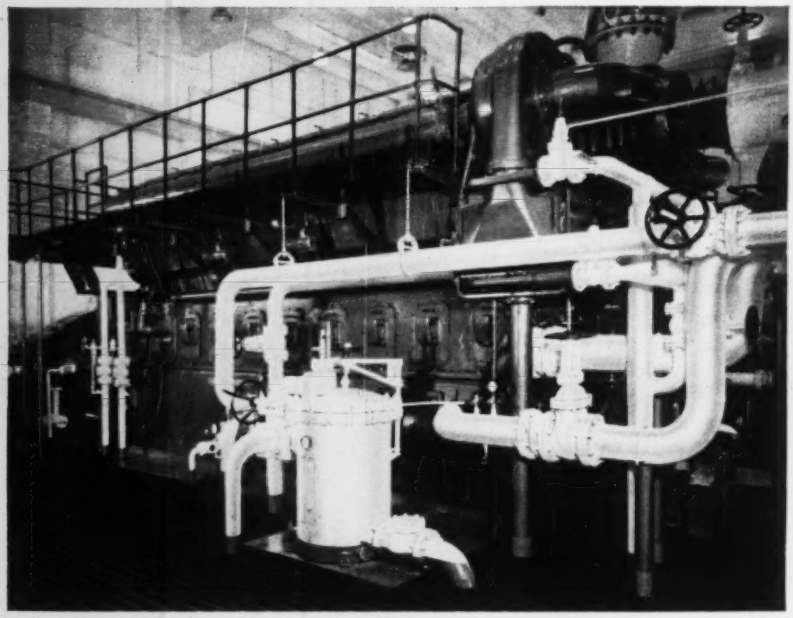
NEW EQUIPMENT BUSINESS NOTES LATEST CATALOGS

Gate Valves

NIBCO Inc. is distributing Catalog VC-3, Supplement H, containing descriptive and size data for "Husky" gate valves. Tables of recommended service and pressure data are included. —K-67

Dust Control

Catalog G 100 of the Western Precipitation Div. of Joy Mfg. Co. describes and illustrates the various precipitators, collectors, filters, scrubbers, processors, and heaters manufactured for dust and fume control. —K-68



Nugent *Full-Flow* Lube Oil Filtering — essential where service must be continuous

Continuous operating, heavy-duty, pipe line compressor equipment demands completely filtered lube oil to ensure maintenance-free, long-life . . . For this type of service Nugent Laminated Disc Type Full Flow Filters are ideal.

Nugent Fig. 1555 filters filter all the lube oil in circulation, every cycle . . . dirt and foreign solids, as small as 2 microns, are removed quickly as they enter the oil, before they can cause excessive wear . . . yet, detergent additives are unaffected.

Shown above is a Nugent Fig. 1555 size 4L12, one of sixty Nugent filters installed for Columbia Gulf Transmission Company of Houston, Texas. These filters protect: natural gas engines, speed increaser gears, and centrifugal compressors in five remote controlled automatic pipeline stations.

The fine record of efficiency established by these stations is one more example of how Nugent Filters can be used to lengthen the service life of your valuable equipment . . . reduce downtime . . . cut maintenance cost. Let us show you how. Write for information today.

Nugent Fig. 1555—4L recharge, before and after use. Expected life between 2000 and 2500 hrs. Used charge retains approximately 19½ lbs. of foreign matter.

461

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SIGHT FEED VALVES • FLOW INDICATORS

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Vertical Duplex Pumps

Industrial Sales Dept., John Bean Div. of Food Machinery and Chemical Corp., is distributing a folder giving essential descriptive and engineering information on various types of vertical duplex pumps manufactured by the division. These pumps are designed for general purpose high pressure pumping operations requiring capacities up to 7 gpm at pressures up to 5000 psi and temperatures to 160 F. —K-69

Reversing Valves

The advantages of 3-way reversing valves for heat pump and hot gas applications of Freons-NH3- and so on are outlined in a folder which is now available from Hubbell Corp.. Application of Type RA-3- way common inlet solenoid valve is shown diagrammatically. —K-70

Drilling and Tapping

Proper procedures for drilling and tapping aluminum, magnesium, steel, thermoplastics and other plastics to receive Heli-Coil inserts are described in a bulletin, No. 765, published by Heli-Coil Corp.

In addition to basic drilling and tapping procedures, the bulletin treats such specific information as proper selection of tap for boss material, tapping lubricants, close-in characteristics of magnesium, and class of fit. A complete "H" limits chart for both aluminum and steel cutting taps is included.

The bulletin features a unique nomograph from which one can easily determine the tapping speed and lubricant for a given size of tapped thread in a wide range of materials. It also discusses many tapping problems, their causes and suggested remedies. —K-71

Atmospheric Burners

A 14-page illustrated Bulletin No. H-1, issued by the Combustion Div. of Eclipse Fuel Engineering Co., presents eight atmospheric gas-fired burners with maximum firing capacities from 10,000 to 2,750,000 Btu/hr.

The bulletin provides dimensions, specifications, engineering data, and ordering information for pipe, wheel, immersion, ring box, and U-type burners, atmospheric injectors, and packaged burners. Burner accessories include gap-type burner nozzles, mounting cages, and a draft-compensating pilot.

An introduction to the operating principle of atmospheric burners, instructions for building atmospheric-combustion systems, and illustrated description of six typical burner installations also is included. —K-72

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K-5	K-14	K-23	K-32	K-41	K-50	K-59	K-68
K-6	K-15	K-24	K-33	K-42	K-51	K-60	K-69
K-7	K-16	K-25	K-34	K-43	K-52	K-61	K-70
K-8	K-17	K-26	K-35	K-44	K-53	K-62	K-71
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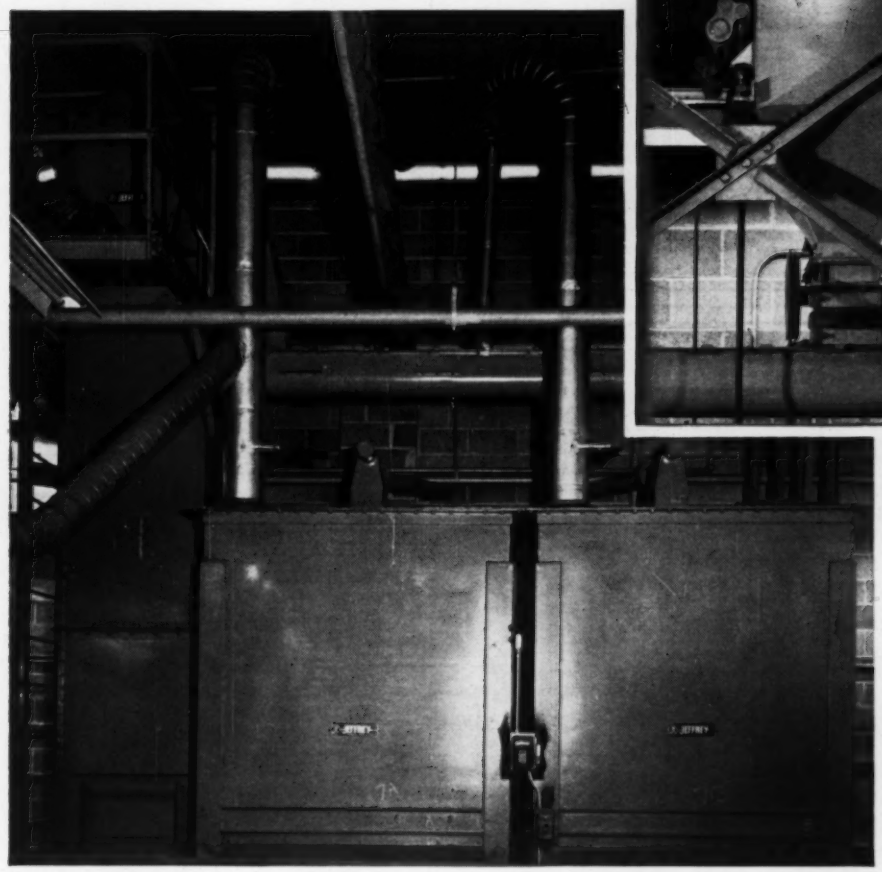
Jeffrey system eliminates manual handling of lead oxide at Universal Battery plant

Tank trucks deliver lead oxide to Universal Battery Company's new plant in Chicago, where it is transferred to storage by air. No more back-straining handling of 600-pound drums. The Jeffrey system of storing, elevating, weigh blending and conveying has eliminated all manual handling in these operations.

Jeffrey furnished this equipment: the storage tank for the lead oxide, a bucket elevator to lift it to the spiral conveyor that feeds the Jeffrey weigh bin, and two rotary vane feeders. From tank truck to Simpson mixer, push button-control takes care of every phase of the system.

Planned by A. Epstein & Sons Inc. of Chicago, this installation combines that engineering firm's materials handling know-how and the proven dependability of Jeffrey products. The Jeffrey Manufacturing Company, 915 North Fourth Street, Columbus 16, Ohio.

From this Jeffrey weigh bin, batches are delivered to the Simpson mixer by the Jeffrey spiral conveyor.



Jeffrey bucket elevator lifts lead oxide to the spiral conveyor feeding the Jeffrey weigh bin.

If it's conveyed, processed or mined, it's a job for JEFFREY

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1960 TRANSACTIONS OF THE ASME

Here, in three sections, are the 371 papers and discussions published in the five 1960 Transactions Quarterlies. But more important, by far, is the fact that these contributions have been written by authorities in the laboratories, production centers, and field stations where engineering takes its first forward steps—thus making the book a reference of immediate as well as long term value to every mechanical engineer regardless of his specialty.

Section 1
POWER AND INDUSTRY

Sponsors for the presentation of the papers in this Section, titles at right, are—

ASME Professional Divisions for

Fuels . Gas Turbine Power . Nuclear Engineering . Power . Aviation . Machine Design . Petroleum . Production Engineering . Process Industries Rubber and Plastics . Textile.

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Air Pollution . Corrosion and Deposits From Combustion Gases . High Temperature Generation Investigation . Power Test Codes . Solar Energy Application . Hydraulic Prime Movers . Pumping Machinery.

Development of a Three-Stage Liquid-Cooled Gas Turbine
Effect of Ambient and Fuel Pressure on Spray Drop Size
Presentation of a Blade-Design Method for Axial-Flow Turbines Including Design and Test Results of a Typical Axial-Flow Stage
Basic Heat Transfer and Flow Friction Characteristics of Six Compact High-Performance Heat Transfer Surfaces
Metallurgical Evaluation of Superheater-Tube Alloys After Six Months' Exposure at Temperatures of 1100 to 1500 F
Blast-Furnace Gas Cleaning for Iron and Ferromanganese Production
Influence Coefficients for Open-Crown Hemispheres
Critical Flow Velocities for Collapse of Reactor Parallel-Plate Fuel Assemblies
Propeller Turbines of the St. Lawrence Power Project
Influence of Trailing-Edge Geometry on Hydraulic-Turbine Blade Vibration Resulting from Vortex Excitation
Water-Hammer Damage to Oigawa Power Station
An Experimental Investigation of Radial Thrust in Centrifugal Pumps
Design and Test of Mixed-Flow and Centrifugal Impellers
Volute Pressure Distribution, Radial Force on the Impeller, and Volute Mixing Losses of a Radial-Flow Centrifugal Pump
Relationship of Coal-Ash Viscosity to Chemical Composition
Pressurization of Granular Solid Fuels
Experimental Investigation of Fuel Additives in a Supercharged Boiler
External Corrosion of Superheaters in Boilers Firing High-Alkali Coals
Corrosion of Superheaters and Reheaters of Pulverized-Coal-Fired Boilers
Considerations for the Reduction of Noise in Ship Installations of Gas Turbines
A Torsional Vibration Problem as Associated With Synchronous Motor-Driven Machines
Design Control of Overcompression in Rotary Vane Compressors
Operation of Steam Turbines to Minimize Shell Cracking
Throat Tap Nozzles Used for Accurate Flow Measurements
Water Treatment, Corrosion, and Internal-Deposit Studies for Eddystone
Selection of Materials and Fabricating Techniques for the Eddystone Boiler and Sulzer Control Valves
Development Associated With the Superpressure Turbine for Eddystone Station Unit No. 1
Material Selection and Fabrication, Main Steam Piping for Eddystone No. 1, 1200 F and 5000 Psi Service
Solar Turbo Power Plant Design
Analysis of Solar-Furnace Performance in Mechanical Testing at Extremely High Temperatures

Design and Analysis of Welded Pressure-Vessel Skirt Supports
Static Testing High-Pressure Piping Components
Tire Testing
Nomographic Synthesis of Generator Linkages
Effect of Presetting Helical Compression Springs
A Quantitative Investigation of the Factors Which Influence the Fatigue Life of a V-Belt
Edge Influence Coefficients for Toroidal Shells of Positive and Negative Gaussian Curvature
Influence of Surface Residual Stress on Fatigue Limit of Titanium

Shear-Zone Size, Compressive Stress, and Shear Strain in Metal Cutting and Their Effects on Mean Shear Flow Stress
Simplified Approach to Understanding the Suction Problems for Reciprocating Mud Pumps
Prevention of Sulfide-Stress Cracking in Sour Condensate Well Equipment
Overstrain Tests on Thick-Walled Cylinders
Analytical Study of Drill-String Vibration
Experimental Study of Drill-String Vibration
The Theory of the Ideal Design of a Compound Vessel
Strength of Thick Cylinders Subjected to Repeated Internal Pressure
Interaction of Textile Structures and High-Speed Textile Processes
Effect of Transient Loads on the Refrigerated-Space Temperature of a Cooling Complex
Uniform Two-Way Orientation of Plastic Films
Synthesis of Epicyclic Gear Trains Using the Velocity Ratio Spectrum
Helixform Bevel and Hypoid Gears
Twinworm Drive—A Self-Locking Worm-Gear Transmission of High Efficiency
Determination of Cutter Trajectories for Contoured Turbine Buckets
Analysis of Factors Used for Strength Rating Helical Gears
Bending Strength of Gear Teeth by Cantilever-Plate Theory
Rocket Motor Gear Tooth Analysis (Hertzian Contact Stresses and Times)
Analysis of Power Spinning of Cones
Some Problems of Press Forging Lead and Aluminum
Deformation Process in Metal Cutting
Influence Coefficients and Pressure Vessel Analysis
Tube Metal Temperatures for Structural Design
Supersonic Wind-Tunnel Air-Drying-System Design
Tensile and Short-Time Creep Properties of N-155 Alloy Sheet
Photoelastic Analysis of Machining Stresses
Correlation of Bendability of Materials With Their Tensile Properties
Comparisons Between the Shearing Properties of Alpha-Brass as Derived From the Cutting Process and From Static and Impact Torsion Tests
Role of Friction in Metal Cutting
Critical Comparison of Metal-Cutting Theories With New Experimental Data
New Developments in the Theory of the Metal-Cutting Process, Part I
Structural Weight Approximation for a Bell-Nozzle Divergent Section
Optimum Tolerances of Sheet Materials for Flight Vehicles
Mechanical Vibration Filters With Nonlinear Characteristics
Refinement of Finite Difference Calculations in Kinematic Analysis
The Measurement of Very Low Frictional Torques in Rotating Equipment
Design by Quantitative Factor of Safety
Study of Critical Velocity of Stick-Slip Sliding
Inertial Effects in a Multiple-Ball Transmission
Some Applications of the Cycloid in Machine Design
A Discussion of the Vibration Characteristics of a Simple Mechanical Connection
Deformation and Moments in Elastically Restrained Circular Plates Under Arbitrary Load or Linear Thermal Gradient
Dimensionless Parameters for Helical Compression Springs

Section 2
HEAT TRANSFER and BASIC ENGINEERING

Papers in this Section, listed at left, were presented under the sponsorship of—

ASME Professional Divisions for

Heat Transfer . Hydraulics . Instruments and Regulators . Lubrication . Metals Engineering.

Research Committees on

Effect of Temperature upon the Properties of Metals . Fluid Meters . Mechanical Pressure Elements.

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Measurement of the Thermal Conductivities of Gases at High Temperatures
Laminar Transfer From Isothermal Spanwise Strips on a Flat Plate
Spectral Characteristics of Fabrics From 1 to 23 Microns
Heat Transfer From Transverse and Yawed Cylinders in Continuum, Slip, and Free Molecule Air Flows
Magnetohydrodynamic Effects Upon Heat Transfer for Laminar Flow Across a Flat Plate
Conical Turbulent Boundary Layer Experiments and a Correlation With Flat Plate Data
Influence of Free Stream Turbulence on the Local Heat Transfer From Cylinders
Heat Transfer to Fully Developed Laminar Flow in a Circular Tube With Arbitrary Circumferential Heat Flux
Steam Slip—Theoretical Prediction From Momentum Model
Pressure Drop and Heat Transfer in a Duct With Triangular Cross Section
Heat Transfer in Flow Through Rotating Ducts
A Variable Density Single-Fluid Model for Two-Phase Flow With Particular Reference to Steam-Water Flow
Transient Temperatures and Thermal Stresses in Hollow Cylinders Due to Heat Generation
Thermal Contact Resistance in Finned Tubing
Mass Transfer, Flow, and Heat Transfer About a Rotating Disk
Heat Transfer and Effectiveness for a Turbulent Boundary Layer With Tangential Fluid Injection
Sublimation Mass Transfer Through Compressible Boundary Layers on a Flat Plate
Laminar Skin Friction and Heat Transfer on Flat Plates With Wedge-Shaped Grooves in Flow Direction
Heat Transfer to Liquid Metals With Variable Properties
Summary of Experiments on Turbulent Heat Transfer From a Non-isothermal Flat Plate
Experimental Study of the Effects of Nonuniform Wall Temperature on Heat Transfer in Laminar and Turbulent Axisymmetric Flow Along a Cylinder
Geometric Factors for Radiative Heat Transfer Through an Absorbing Medium in Cartesian Coordinates
Thermal Radiation From a Cylindrical Enclosure With Specified Wall Heat Flux
Application of Variational Methods to Radiation Heat-Transfer Calculations
Certain Thermodynamic and Transport Properties of the Atmospheres of Venus, Mars, and Jupiter
Rocket Heat-Transfer Literature
Unsteady Turbulent Heat Transfer in Tubes
Improved Lumped-Parameter Method for Transient Heat Conduction Calculations
Local and Average Heat Transfer and Pressure Drop for Refrigerants Evaporating in Horizontal Tubes
Heat-Transfer and Flow-Friction Characteristics of Crossed-Rod Matrices
Experiments on Heat Transfer From Spheres Including Combined Natural and Forced Convection
Heat Transfer to Freon 12 Near the Critical State in a Natural-Circulation Loop

Combined Free and Forced Convection Heat Generating Laminar Flow Inside Vertical Pipes With Circular Sector Cross Sections
On Combined Free and Forced Convection in Channels
The Role of the Skin in Heat Transfer
The Prediction of Human Thermal Tolerance When Using a Ventilating Garment With an Antiexposure Suit

TECHNICAL BRIEFS

Effect of Vapor Drag on Rotating Condensation
Radiation Fin Effectiveness
Tabulation of the Function $\exp X^2 \operatorname{erfc} X$
Comparison of Turbulent Heat-Transfer Results for Uniform Wall Heat Flux and Uniform Wall Temperature
Heat Transfer by Laminar Flow From a Rotating Cone
Apparent Emissivity and Heat Transfer in a Long Cylindrical Hole
Variable-Density Single-Fluid Model for Two-Phase Flow
Nearly Quasi-Steady Free Convection Heat Transfer in Gases
Effect of Mass Transfer on Free Convection
Interferometric Method of Studying Boundary Layer Oscillations
Heat Transfer to Boiling Mercury
Temperature Distribution and Heat-Transfer Results for an Internally Cooled, Heat Generating Solid
Effects of Initial Boundary-Layer Thickness on a Tangential Injection System
Mechanism of Sound Field Effects on Heat Transfer
Transducer for the Measurement of Heat-Flow Rate

Cavitation Effect on the Discharge Coefficient of the Sharp-Edged Orifice Plate
Measurement of Oil-Film Thickness Between Disks by Electrical Conductivity
Performance Characteristics of Lubricating Oil Film Between Rotating Disks
Measurement of Oil-Film Thickness in Gear Teeth
A New Approach to Linear Filtering and Prediction Problems
Shannon's Theory and Feedback Systems
Dynamic Response and Control of Multipass Heat Exchangers
Bang-Bang Versus Linear Control of a Second-Order Rate-Type Servomotor
Design and Analysis of a Servovalve With Flow Feedback
Unsteady Transfer of Momentum and Heat Between Concentric Cylinders
Chamber Dimension Effects on Induced Flow and Frictional Resistance of Enclosed Rotating Disks
Three-Dimensional Turbulent Boundary Layer Generated by Secondary Flow
Thermocouple System for Measuring Turbine-Inlet Temperatures
Estimating the Roots of the Characteristic Determinant for Multicoupled Systems
Human Body as an Inconstant Heat Source and Its Relation to Clothes Insulation, Parts 1 and 2
Some General Considerations in Process Optimization
Ejector-Nozzle Flow and Thrust
Pressure Losses in Smooth Pipe Bends
Discharge Coefficients and Steady-State Flow Forces for Hydraulic Poppet Valves
Crossover Systems Between the Stages of Centrifugal Compressors

Section 3
APPLIED MECHANICS

Here are reports of fundamental, analytical and experimental studies which were presented at Society meetings and conferences under the sponsorship of the ASME Applied Mechanics Division. The problems covered are those associated with buckling, deformation, elasticity, flow of fluids, kinematics, plasticity, plates, stresses and strains, structures, thermal stresses, vibration, wave mechanics.

Other valuable information in this Section includes design data drawn chiefly from previously published Applied Mechanics papers, brief articles on technical matters in mechanics, and reviews of important new books of the field.

A Theory of Lubrication With Turbulent Flow and Its Application to Slider Bearing
Effect of the Wall on Two-Phase Turbulent Motion
Melting of Finite Slabs
Heat-Exchanger Tube-Sheet Design—3. U-Tube and Bayonet-Tube Sheets
Mechanics of the Sheet-Bending Process
Relaxation of a Cylinder on a Rigid Shaft
Strain-Hardening Solutions to Axisymmetric Disks and Tubes
Effect of Shear Deformation on Bending of Rectangular Plates
Plastic Stress Concentration at a Circular Hole in an Infinite Sheet Subjected to Equal Biaxial Tension
Stresses in the Plastic Range Around a Normally Loaded Circular Hole in an Infinite Sheet
Dynamical Saint Venant Principle
Correlation of Theoretical and Photothermoelastic Results on Thermal Stresses in Idealized Wing Structures
Stresses in a Circular Cylinder Having an Infinite Row of Spherical Cavities Under Tension
Transient Thermal Stresses in a Semi-Infinite Slab
Stress-Strain Relations and Strain-Energy Expressions in the Theory of Thin Elastic Shells
Effect of Shear on Plastic Deformation of Beams Under Transverse Impact Loading
The Half Space Under Pressure Distributed Over an Elliptical Portion of Its Plane Boundary
Earth Motion Beneath a Prescribed Boundary Displacement
Elastic Bending of Columns Due to Dynamic Axial Forces Including Effects of Axial Inertia
Dominance of Shear Stresses in Early Stages of Impulsive Motion of Beams
Elastic-Plastic Response of Thin Spherical Shells to Internal Blast Loading
Assessment of Flow Disturbances and Blunt Body Traveling at Supersonic Speeds Owing to Flow Disturbances in Free Stream
Possible Similarity Solutions for Laminar Free Convection on Vertical Plates and Cylinders
Annual Damper for a Freely Precessing Gyroscope
Heat Transfer for Laminar Flow in Ducts With Arbitrary Time Variations in Wall Temperature
Study of the Stability of Externally Pressurized Gas Bearings
Theoretical Analysis of a Dynamic Thermocouple: 2—The Continuous Area Interface
Normal Modes of Nonlinear Dual-Mode Systems
Classical Normal Modes in Damped Linear Dynamic Systems
Vibration Response of a Linear Undamped System Resting on a Nonlinear Spring
Approximate Analysis of Certain Boundary-Value Problems
Stresses in a Slab Having a Spherical Cavity Under Circular Bending
Elastic Equilibrium of a Plate With a Reinforced Elliptical Hole
Method of Solution for the Elastic Quarter-Plane
Thermal Stress in a Viscoelastic-Plastic Plate With Temperature-Dependent Yield Stress
Prediction of Creep Failure Time for Pressure Vessels
Plastic Behavior of Rotating Cylinders
Optimum Design of Shells
Yield Conditions for Rotationally Symmetric Shells Under Axisymmetric Loading
Approximate Analysis of the Influence of Aerodynamic Heating and Initial Twist on the Torsional Stiffness of Thin Wings
Postbuckling Behavior of Rectangular Plates With Small Initial Curvature Loaded in Edge Compression
Junction Problem of Solid-Slotted Cylindrical Shells
Three and Two-Dimensional Disturbances of Pipe Flow
Indeterminateness of the Boundary Conditions of the Mixing of Two Parallel Streams
Thermal Transfer in Turbulent Gas Streams. Effect of Turbulence on Local Transport From Spheres
Hydrodynamic Entrance Lengths for Incompressible Laminar Flow in Rectangular Ducts
Stability of a Turbine-Generator Rotor Including the Effects of Certain Types of Steam and Bearing Excitations
Saint Venant's Principle: Elastic Shells and Plates
Airy Stress Functions of Plane Dislocation Problems
Effect of Pressure on Bending Characteristics of Actuator System
Contact Problem for Viscoelastic Bodies
Stresses in Curved Beams of Noncircular Center Line
Shear Buckling of Bars
Buckling of Circular Cones Under Axial Compression
Additional Deflection of a Cantilever Due to Elasticity of Support
Thermoelastic Stresses in Beams
Elastic Instability of Rectangular Sandwich Panel of Orthotropic Core With Different Face Thicknesses and Materials
Transient and Residual Thermal Stresses in an Elastic-Plastic Cylinder
Strain-Hardened Circular Cylindrical Shells
Elastoplastic Thick-Walled Sphere Subjected to a Radial Temperature Gradient
Rupture Instability of Plane Membranes and Solids
Expansion of Thick-Walled Cylinders Fabricated From Cold Bent Plates
Dispersion of Flexural Waves in an Elastic, Circular Cylinder
Modeling of Large Transient Elastic and Plastic Deformations of Structures Subjected to Blast Loading
Shock Spectra of a Nonlinear System
Forced Flexural Vibrations of Sandwich Plates in Plane Strain
Extensional Vibrations and Waves in a Circular Disk and a Semi-Infinite Plate
Effect of Small Hub-Radius Change on Bending Frequencies of a Rotating Beam
Forced Lateral Vibration of a Uniform Cantilever Beam With Internal and External Damping
A Method for Investigating Certain Eigenvalue Problems of the Buckling and Vibration of Plates
Dynamical Response of an Elastic Half-Space to Tangential Surface Loadings
Special Class of Self-Sustained Oscillations
Random Excitation of a Loaded Nonlinear String
Use of Nonsinusoidal Approximating Functions for Nonlinear Oscillation Problems
Two-Dimensional Gas Jets
Compressibility Effects of the Lubricant for Two-Dimensional Slider Bearings
Heat Transfer and Sublimation at a Stagnation Point in Potential Flow
Transient Heat Conduction in a Rod of Finite Length With Variable Thermal Properties
Transient Conduction in Coaxial Cylinders With Relative Motion and Heat Generation
Thermal Stresses in an Elastic, Work-Hardening Sphere
Axially Symmetric Waves in Elastic Rods
Vibrations and Waves in Elastic Bars of Rectangular Cross Section
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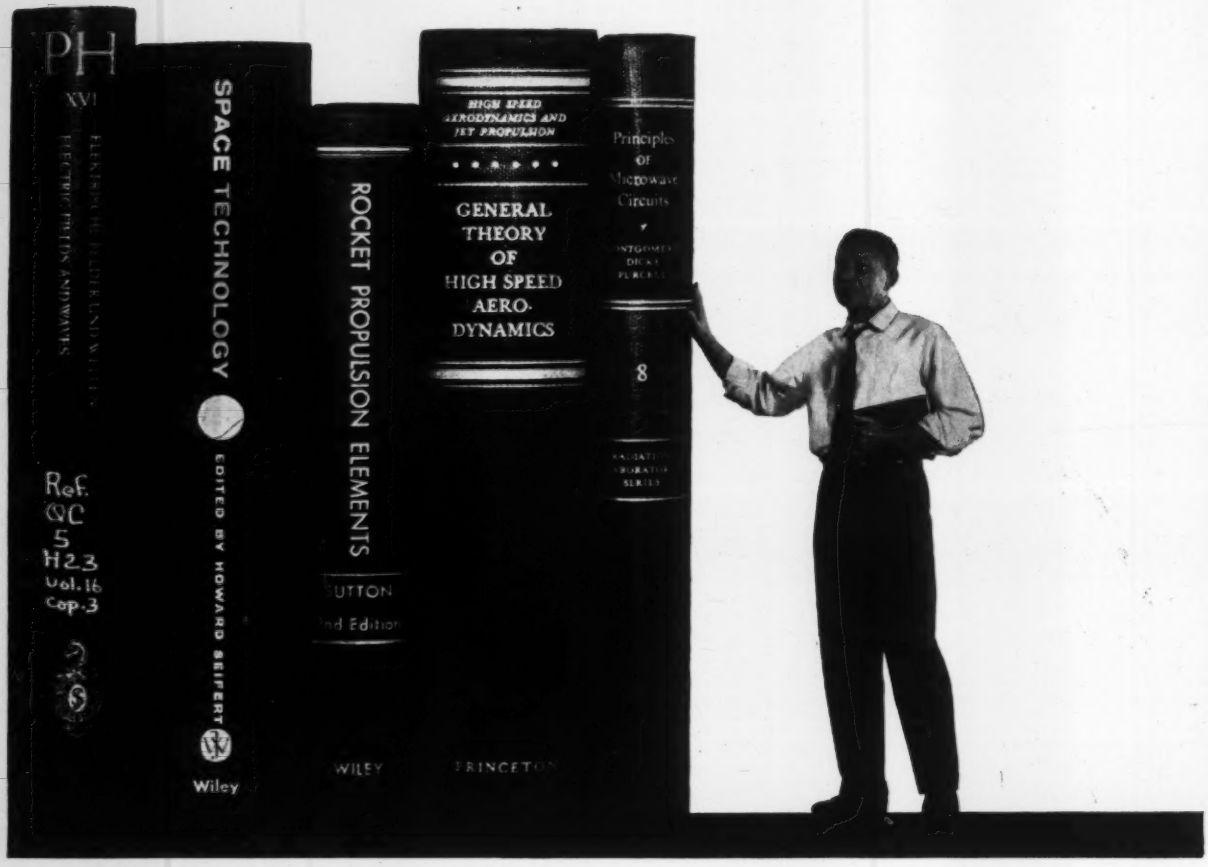

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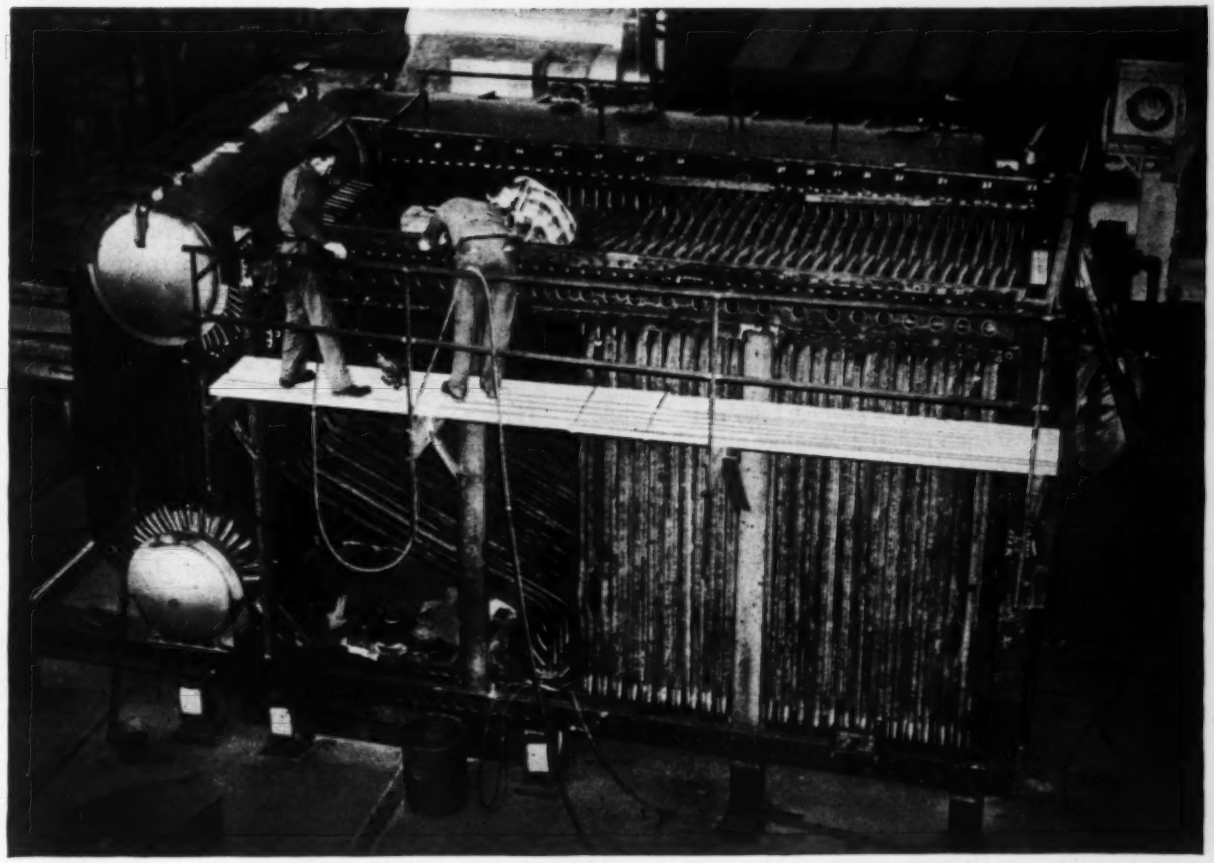

Stoker-fired boiler being shop assembled.

Coal fuels this push-button packaged steam generator

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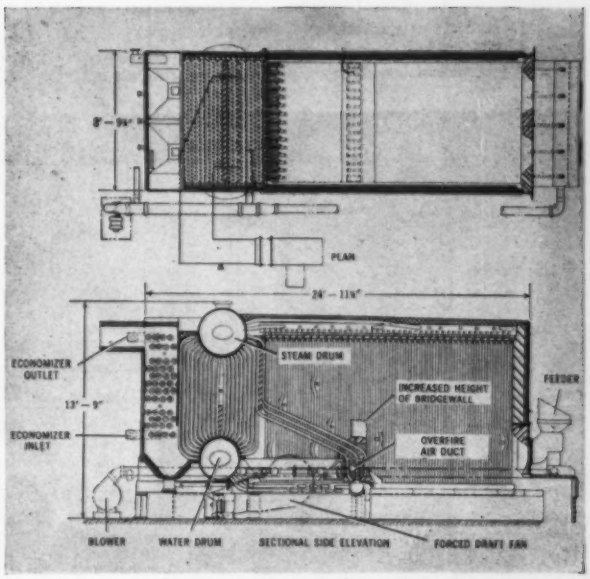
For complete performance and descriptive data on FW stoker-fired packaged steam generators, request bulletin PG59-4. Standard oil and gas fired units are also available in capacities from 13,000 to 100,000 lb/hr. Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.



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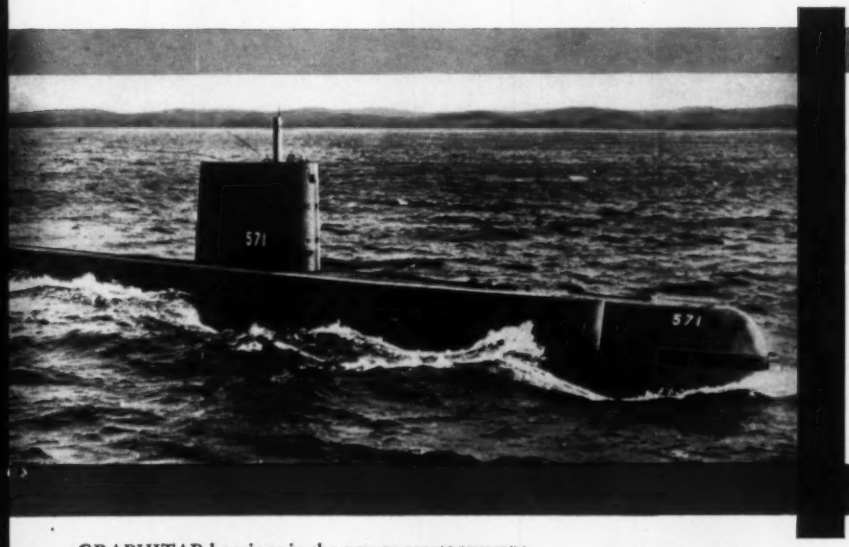
There are other characteristics every bit as important to GRAPHITAR'S dependability. They include chemical and magnetic inertness, mechanical strength and adaptability to self-lubrication. Besides these natural characteristics, GRAPHITAR engineers can control porosity, strength and hardness to match GRAPHITAR'S physical properties to each individual application. It's little wonder that GRAPHITAR has become one of the design engineer's most versatile and useful materials.

In this laboratory test stand, oxidation-resistant GRAPHITAR parts are being checked under simulated operating conditions. Similar tests have proven that, when GRAPHITAR parts are exposed in oxidizing atmospheres at 1,200°F., they show only a weight loss of less than six percent after 200 hours.

With the aid of photomicrographs, engineers at The United States Graphite Company gain valuable information about the microstructure of GRAPHITAR parts. Modern laboratory equipment such as the Metallograph enables engineering personnel to advance product quality for maximum dependability. Extensive and continuing R&D work has always been an integral part of The United States Graphite Company's operations.

GRAPHITAR air/oil seals employed in today's high-speed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.



GRAPHITAR bearings in the power reactor pumps of American nuclear submarines have compiled an outstanding record for dependability.

Unusually shaped parts of GRAPHITAR can be molded easily with today's modern techniques. Ears, face slots and outside diameter notches of friction disc above, left, were molded in one operation without need for secondary machining and finishing.

Do you have an application in which GRAPHITAR'S dependability can help solve a tough problem, reduce your costs and improve the operational life of your products? Our engineering staff can help you find out. Our field men can also give specialized, on-the-job consultation. Send for your free copy of Engineering Bulletin #20. Included is helpful information about the properties, characteristics and applications of GRAPHITAR.

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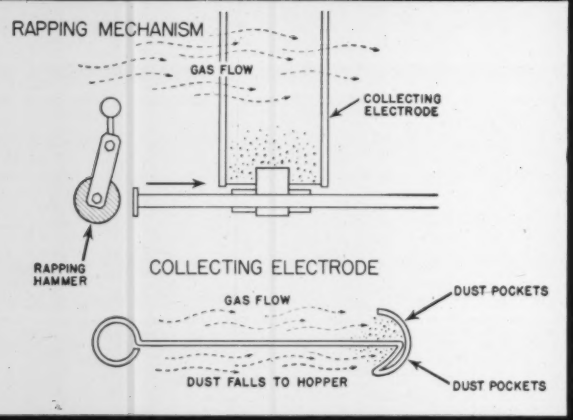
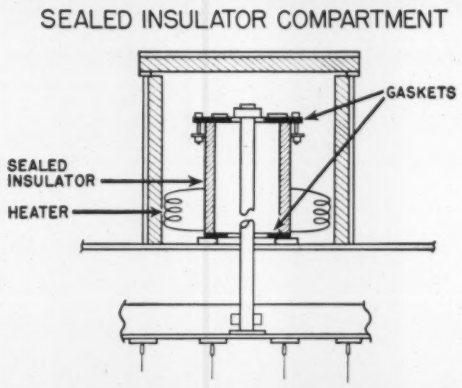
SOME PLAIN FACTS

ABOUT SUPERIOR PRECIPITATOR PERFORMANCE

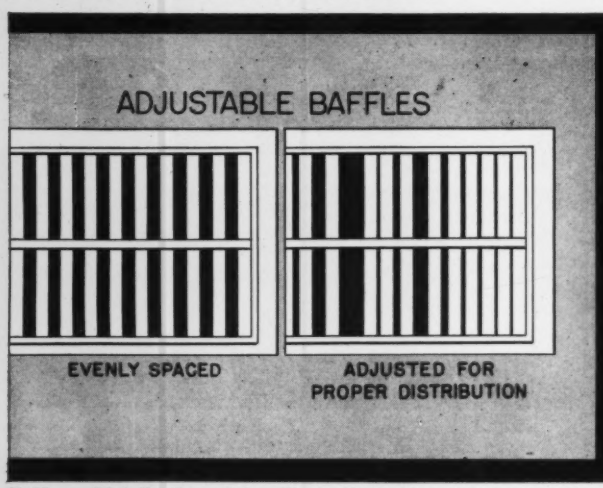
Buell Precipitators are designed and constructed for rugged service and superior performance. Frills and internal frim-fram of a doubtful value are eliminated in favor of strength and simplicity. The casing, outside supports, and internal parts are of rugged construction; and the four-point suspension of emitting electrodes ensures the greatest stability. Here are just a few of the outstanding features of Buell Precipitators.





Effective Continuous Cycle Rapping—Yes, it's mechanical. A simple, rugged system free of complicated gadgets; assures positive dust shearing action. Each row of electrodes is rapped separately—in the direction of the gas flow—on a continuous cycle. Dust is sheared off, drops in an agglomerated mass and pockets on electrodes minimize reentrainment.

Sealed Insulators Improves Operation—High voltage quartz support insulators are completely sealed; prevents gas and dust leaking into insulator compartment and outside air leaking into precipitator. There is no need for costly ventilating systems. Thermostatically controlled electric heaters insure start-up without danger of moisture condensation and insulator breakdown.



Uniform Distribution of Gas Flow—Field adjustment capability is vital. Buell's adjustable baffle permits final positioning after field measurement of actual flow distribution . . . because gas flow patterns are not entirely predictable. The Buell distribution system assures equal gas loading through the precipitator; eliminates ineffective "dead" areas around passages and prevents "sneak-by."

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Buell precipitators are simple and effective. They're designed for continuous service. You'll be glad you turned to Buell when you experience superior performance and low maintenance. Detailed literature describing all features is available.

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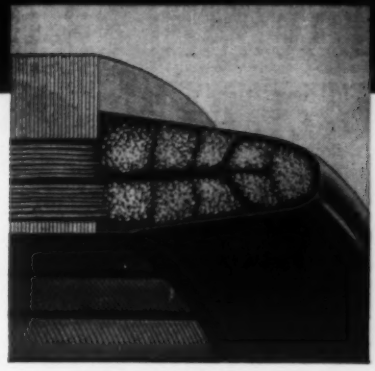

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MECHANICAL ENGINEERING

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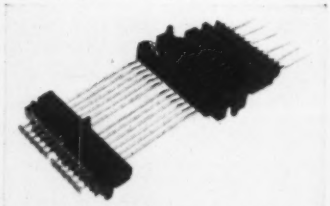
Hardly larger than cigarette packages, wire spring relays form the heart of switching apparatus for more than 200-million telephone calls a day. The pencil indicates the top row of tiny palladium-capped contacts which are vital to the relay's switching functions.

Probing for palladium via thermoelectricity

Wire spring relays are vital to the Bell Telephone System's reliable, high-speed switching equipment. Western Electric will manufacture more than 13 million relays in 1961. Palladium-capped contacts on these relays are necessary for their optimum performance—therefore, positive verification of the palladium is essential.

Verification by existing means has proved to be extremely difficult, however, because of the caps' size (only 1.01 x 0.73 x 0.042 inches) and the fact that the palladium and the cupro-nickel base blocks to which the caps are welded are similar in color, making visual checking highly unsatisfactory. Also, the characteristics of the metals involved make ordinary electrical and magnetic methods impractical.



The single wire block — a component of the wire spring relay — showing the cupro-nickel contact points, some of which must be capped with palladium.

Contact verification machine, developed and built by Western Electric, being programmed to check wire blocks for dielectric breakdown, physical configuration, and palladium contacts.

To overcome this problem, Western Electric engineers have developed and built an ingenious machine which utilizes the Seebeck thermoelectric effect, by which an electrical circuit made up of two different metals generates an electric current when the junction between the two metals is heated. In this case, nickel and palladium were the metals involved, but another feature of the Seebeck effect is that a circuit composed of nickel and cupro-nickel generates a current *which flows in the opposite direction.*

The engineers made use of this feature by using nickel probes — preheated to 300 degrees Fahrenheit — in the new machine. The probes touch all contacts on the relay's single wire block assembly, and the *direction* of the current produced indicates whether the probe has contacted palladium or the cupro-nickel base metal. Amplifier circuits enable the "indicator" currents to operate automatic controls and automatically reject defective assemblies.

Being able to intentionally leave caps off certain pre-selected contacts is also a prime advantage of this new verification process, since hundreds of thousands of relays use less than the maximum number of contacts. Savings in material costs, which are made possible by omitting precious palladium from unused contacts, are significant. But the most important advantage of the process is the proven ability to produce a product with verified quality — the kind of quality required by the Bell System's twenty-three local telephone companies to give highly dependable telephone service.

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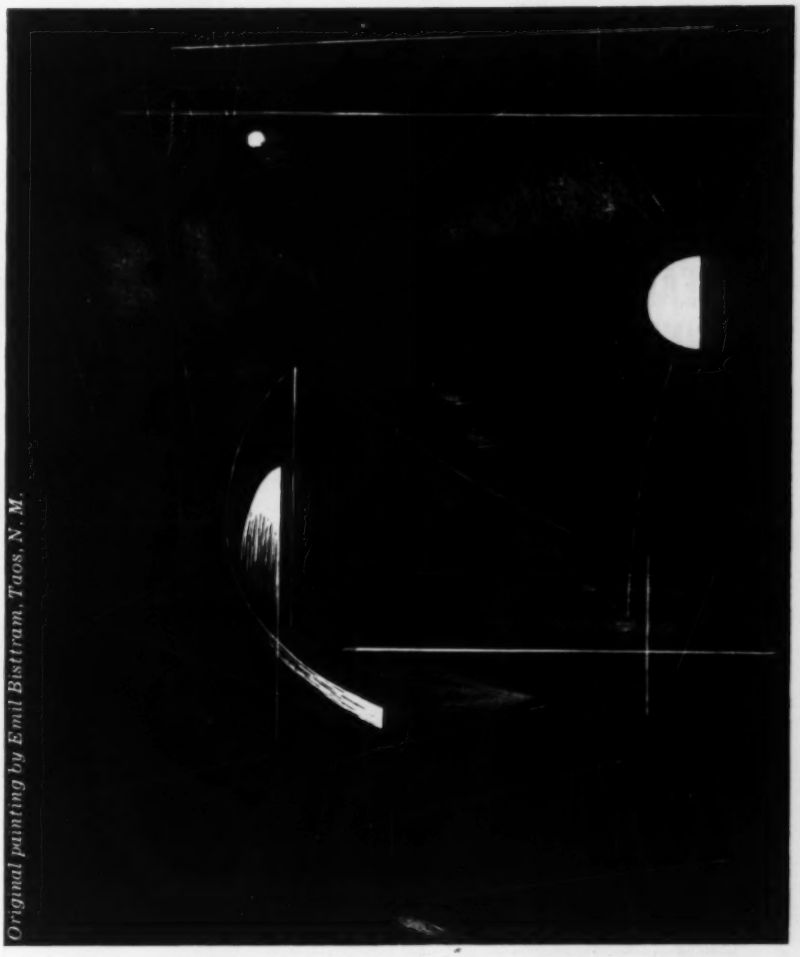

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Excerpt: A special Report of the U.S. Atomic Energy Commission, January 1961 entitled, "Atomic Energy Research in the Life and Physical Sciences, 1960."

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Nice Ball Bearing Co.
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Pace Engineering Co.
Pacific Pumps, Inc.
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*Philbrick, George A., Researches, Inc.
Pipe Fabrication Institute
Pulsation Controls Corp.

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Stock Equipment Co.
Streeter-Amet Co.

*Terry Steam Turbine Co.

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Union Bonnet and Cylindrical Body Increase Valve Life . . .

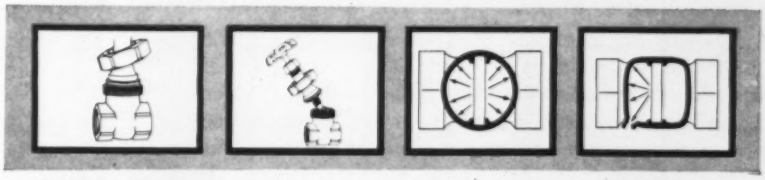
Heavy bronze union bonnet ring is entirely separate from the bonnet to eliminate any possibility of springing the bonnet face when assembling or disassembling the valve.

Cylindrical body withstands sudden pressure. This construction resists rupture and minimizes deflection when under severe pressure. Pressure in ordinary valve bodies tries to push the body wall out. Rupturing stresses concentrate where wall has the shortest radius. This deflection causes early valve failure in ordinary valves.

● *Write today for complete details.*

Fig. 525

125 lb. S.W.P. Bronze Gate Valve
Union Bonnet ● Rising Stem
Inside Screw ● Wedge Disc



Kennedy's Union Bonnet permits repeated dismantling for cleaning or inspection and reassembly without danger of distortion of the valve. The bronze-to-bronze construction makes a tight union for tight, leakproof operation.

Kennedy's Fig. 525 can be easily disassembled into component parts for installation in otherwise inaccessable places in existing lines or for new installations.

Kennedy's cylindrical body construction when under severe pressure resists rupture and minimizes deflection thus preventing leakage at the seat.

Pressure in ordinary non-cylindrical valve bodies tries to push the body wall out to form a circle or cylinder. Rupturing stresses concentrate where wall has the shortest radius. Resultant deflection causes leakage over disc and early failure.

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ELMIRA, NEW YORK
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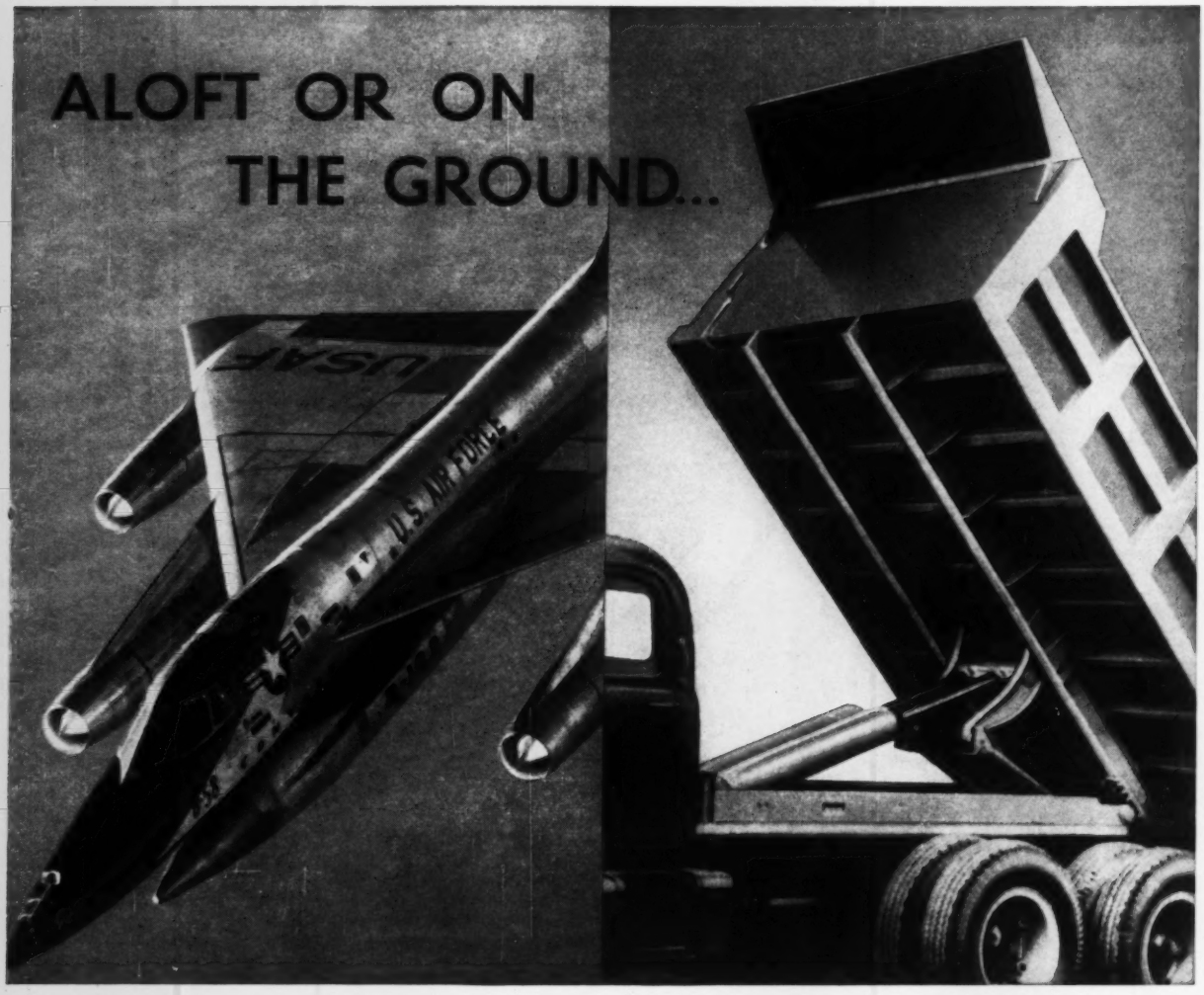

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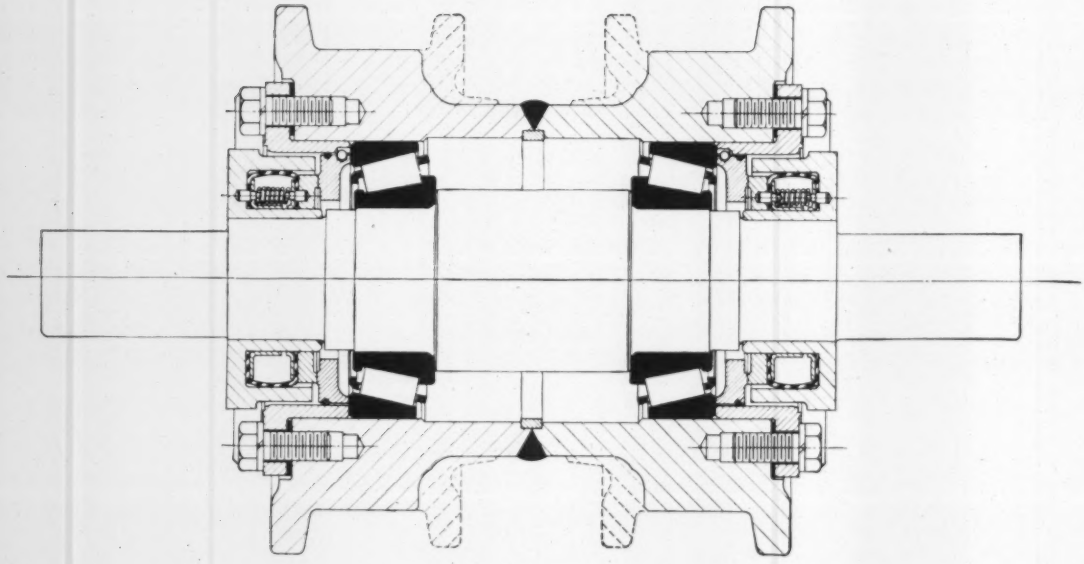
How Allis-Chalmers reduces maintenance, boosts work capacity of their crawler tractors

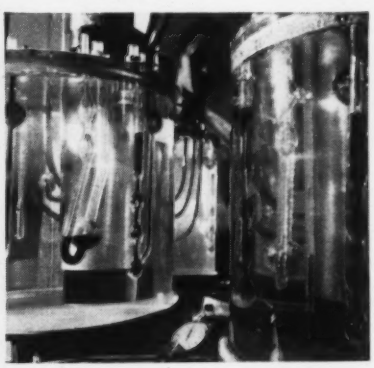


To design *both* greater work capacity and reduced maintenance into their crawler tractors, Allis-Chalmers engineers used Timken® tapered roller bearings for the heavy duty track rollers.

Timken bearings work with the steel sealing rings to effect a positive seal that makes one-time lubrication possible. Timken bearings keep all parts precisely aligned. They protect the seal by minimizing side thrust and wobble, eliminate wear that makes bushing-type assemblies impossible to seal positively. And the tapered design lets Timken bearings take *both* radial and thrust loads. Full-line contact between rollers and races provides extra load-carrying capacity—extra work capacity.

And to deliver more power where it's needed, Timken bearings are also used in the bevel and clutch shaft, final drive pinion, intermediate and sprocket shafts, track idlers and support wheels.

ENGINEERING ASSISTANCE, early in the design stage, helps manufacturers stretch bearing dollars. Timken bearing engineers have the training to do the job and are eager to help you.



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